COMMUNICATION

FROM

18

B. AYCRIGG, CIVIL ENGINEER,

RELATIVE TO THE

WEST BRANCH AND ALLEGHENY

CANAL,

SUPPLEMENTARY TO THE REPORTS ON THE SAME SUBJECT, READ DEC. 15, 1836, AND MARCH 1, 1837.

READ IN THE HOUSE OF REPRESENTATIVES, FEBRUARY 19, 1839.

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COMMUNICATION.

Harrisburg, 19th February 1839.

To the Board of Canal Commissioners of Pennsylvania.

Gentlemen:—I have received the following note:

1. "In the House of Representatives,
February 13, 1839,

"*Resolved*, That the canal commissioners be requested to call on the engineer, Mr. Aycrigg, for any and all information relative to the expediency and practicability of prosecuting the West Branch extension, and lay the same before this house at the earliest possible time.

"*Extract from the Journal.*

"J. SEILER, *Clerk.*

"To the Board of Canal Commissioners."

Canal Commissioners Room,
State Capital, February 15, 1839.

Sir:—The above resolution adopted by the House of Representatives was this day laid before the board, and the secretary ordered to transmit you a copy.

The board request a reply as soon as practicable.

THOMAS L. WILSON, *Secretary.*

B. Aycrigg, Esq.

In accordance with the above, the following is presented:

2. Having no charge of the work at the present time, this cannot be considered an official report, but a communication from a private citizen, who has, without orders and without expense to the commonwealth, pursued his own course in collecting the best authority on the subject in question. As a private citizen, I consider myself entitled to greater latitude and freedom of remark than would be proper in the formal report of an officer.

3. At the time that the late report of work under my charge was made to the board of canal commissioners, it was intended to follow up the remarks that have given rise to the present call for information, (there promised, although not strictly in the line of my official duty,) by entering into a calculation as to the comparison of the two routes. The present main line and the proposed line by way of the West Branch, and to show the difference in distance calculated by their equivalents in the cost of transportation. It is, however suppo-

sed, that it will be more satisfactory to have the result of experience on a larger scale, and I therefore substitute the statement made to me by one who has for years been extensively engaged in transportation, both in this state and in the state of New York.

"The charge for transporting merchandize from New York to Albany, 160 miles on the river, by the use of steam tow boats, is about the same as for 20 miles of the canal.

"The distance from Philadelphia to Pittsburg is equal to 600 miles of canal—to keep up a daily line of freight boats, there is a dead loss of about $15,000 when compared with the Erie canal of New York. The agency and store room at Philadelphia, Columbia, Hollidaysburg, Johnstown and Pittsburg costs about $20,000, while these expenses on the New York canal do not exceed $5,000."

If it be objected that these expenses may be materially reduced by pursuing the course adopted by one of the lines, and carrying the articles in movable car bodies, it is answered by the doubt whether the cost of transporting this dead weight does not equal the difference except that they do not lose by the constant pilfering at the points of trans-shipment.

4. The distances along the present main line from Philadelphia are the following:

Philadelphia to Columbia, (rail road,)	82 miles.
Columbia to Middletown, (point of intersection of the Union canal with state canal,)	18
Philadelphia to Middletown,	100
Middletown to Hollidaysburg, (canal,)	154
Hollidaysburg to Johnstown, (rail road,*)	36
Johnstown to mouth of Kiskiminitas, canal,	75
Philadelphia to Kiskiminitas,	365
Kiskiminitas to Pittsburg,	29
Philadelphia to Pittsburg,	394
Philadelphia to mouth of Kiskiminitas,	365
Kiskiminitas to Red Bank,	35
Philadelphia to Red Bank,	400
Red Bank to Franklin,	60
Philadelphia to Franklin,	460

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* NOTE—This rail road has ten inclined planes, the summit is 2333.17 feet above tide, and 1171 feet above the basin at Johnstown. The heighth of the proposed Sinnemahoning summit is not yet positively fixed, and admits a variation of perhaps ten feet but was taken at a level of 1,406 feet above tide or 927.71 feet lower than the portage summit, 471 feet above basin at Hollidaysburg, and but 244 feet above the basin at Johnstown.

The distances along the canal route are the following :

Philadelphia to Reading, Schuylkill canal,	62 miles.
Reading to Middletown, Union canal,	80
Philadelphia to Middletown,	142
Middletown to Northumberland, Susquehanna canal,	65
Northumberland to end of Tangascootack extension, West Branch canal,	73
Farrandsville to mouth of Sinnemahoning, Sinnemahoning extension, under contract,	33
West Branch and Allegheny connexion, explored in 1836, from mouth of Sinnemahoning to mouth of Red Bank,	128
Philadelphia to mouth of Red Bank,	441
Red Bank to Kittanning, completing the distance of 128 miles on the route to Pittsburg, required to form an entire water communication, when that under contract is completed,	20
Kittanning to mouth of Kiskiminitas, Allegheny feeder now under contract and necessary to supply the present canal,	15
Philadelphia to Kiskiminitas,	476
Kiskiminitas to Pittsburg,	29
Philadelphia to Pittsburg,	505
Philadelphia to mouth of Red Bank,	441
Red Bank to Franklin,	60
Philadelphia to Franklin,	501

5. These are the actual distances—but from the above statement of one of our most intelligent transporters, corroborated by the opinion of another who is also heavily engaged in this business, it appears that the expense by the present line from Philadelphia to Pittsburg, is equal to what it would be on a canal of the same size as the present and 600 miles long. If we substitute this equivalent for the actual distance to Pittsburg, we get the following. Taking a point on the Allegheny as far above the mouth of the Kiskiminitas as Pittsburg is below it, we come within six miles of the mouth of Red Bank, therefore, distance from

Philadelphia to six miles below Red Bank, equals	600 miles
From this point to Red Bank (actual distance,)	6
Philadelphia to mouth of Red Bank,	606
Red Bank to Franklin, (actual distance)	60
Philadelphia to Franklin equals	666

Philadelphia to Pittsburg equal	600
Kiskiminitas from Pittsburg	29
Philadelphia to Kiskiminitas equal	571

But suppose again that it be not found profitable to run larger boats than the present on an interrupted line, while the West Branch route being an entire water communication connected with other channels both natural and artificial, making the whole of great extent, should be increased in size, in proportion to the distance, and prepared for boats of 100 to 120 tons upon the plans proposed Take the calculations of Josiah White, as to the comparative expense of different sized boats.

Coming from such authority, I cannot resist the temptation, and hope that he will excuse the liberty I have taken in quoting the following from a confidential letter, (the whole of which I should like to give if I felt authorized) in answer to the proposition I submitted to him on the subject of the enlargement.

"Allow one cent a ton a mile each way for toll. Rail roads of a good grade will cost three cents a ton. A twenty-five ton navigation two and a half cents. A fifty to sixty tons, one and three-fourth cents. A one hundred tons, one and a half cents. Up Mississippi one cent and insurance in addition. Freight by sea in large ships, one cent and add insurance. But one cent a ton a mile is a great profit to a canal for a large business. Instance the Schuylkill canal at present."

7. If the West Branch route be constructed on the larger plan, although the high average rate of toll that he assumes be demanded, still we find that the expense will be but six-sevenths of the present. The equivalent distances on the present line, therefore, remaining unchanged, (and even supposing an enlargement of that line be found advantageous, the extra expense on the rail-roads and transhipments cannot be avoided,) the distances by the proposed route reduced one-seventh to give their equivalents as compared with a canal of the present size, will produce the following:

Philadelphia	to the	mouth of Red bank,	378 miles.
"	"	Kiskiminitas,	408
"	"	Pittsburgh,	433
"	"	Franklin,	430

These distances, viz. the real distances in miles, the equivalent distances supposing the West Branch route to carry boats no larger than those on the Juniata, (although the locks are at psesent 2 feet wider than those on the Juniata, being 17 in place of 15 feet,) the equivalent distances, supposing the present route to remain unchanged and the West Branch route constructed of the proposed dimensions, together with the difference in miles both real and equivalent, and the proportional expense of the proposed line both without an extra size, and if of larger dimensions when compared with the expense of the present will be distinctly seen from the following table:

8.

	Extra length of proposed line.	Real length of present line.	Real length of proposed line.	Equivalent length of present line.	Real length of proposed line.	Equivalent difference in miles	Ratio of proposed to present line.	Equivalent length of present line.	Equivalent length, of proposed line for 100 tons.	Equivalent difference in miles.	Ratio of proposed to present line.
Philadelphia to Pittsburg,	111	394	505	600	505	95	0.84	600	433	167	0.72
" Franklin,	41	460	501	666	501	165	0.75	666	430	236	0.65
" Kiskiminitas,	111	365	476	571	476	95	0.83	571	408	163	0.70
" Red bank,	41	400	441	606	441	165	0.73	606	378	228	0.62
Middletown to Pittsburg,	69	294	363								
" Franklin,	—1	360	359								

We thus see that if the West Branch route be prepared for large boats, the expense from Philadelphia to the mouth of Red Bank (at which points the two lines meet) will be but 62 per cent. of the present line, and thence to Franklin one-seventh less than by the Kiskiminitas, (since the cargoes would continue in the smaller boats coming from the Kiskiminitas) making the proportion to Franklin a little over five-eighths of the expense by the present route, and to Pittsburg less than three-fourths.

9. Take the statemeut of another transporter owning one of the heavy lines, just furnished in answer to my inquiry, and we find the result not quite so favorable, but still a great difference against the present line:

"At a living profit we find that we can carry 100 pounds 100 miles, for 25 cents on the canal, for 50 cents on the rail roads, and for $1 00 on the turnpike roads. This is the result of five years heavy business in the three modes of conveyance. The three transhipments, viz: at Columbia, Hollidaysburg and Johnstown, equal the expense of 50 miles of canal. Our line averaging one and a half boats per day, say 4,000 tons westward and 3,500 tons eastward, or perhaps total about 8,000 tons, costs for agency and store room at Philadelphia, $8,000, at Columbia, Hollidaysburg and Johnstown, $3,000 each, and at Pittsburg $7,000, total, $24,000. *We now charge $1 00 above the carter's price from Chambersburg to Pittsburg, allowing us 50 cents per 100 lbs. per 100 miles for transportation on the rail roads, and 25 cents for the expenses at the two ends, or at Philadelphia and at Chambersburg."

10. From this statement the rail road transportatation costs double that of the canal. Therefore we get the following equivalent distances:

Philadelphia to Pittsburg (real distance,)	394 miles.
Add length of the two rail roads,	118
Add expense of 3 transhipments, equal	50
Equivalent distance from Philadelphia to Pittsburg,	562

11. The former table would then become by the substitution of 562 miles obtained by the latter, for 600 miles obtained by the former statement, the following, viz:

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*Note.—The canals being closed thus showing the necessity of rail roads as well as canals. B. A.

	Extra length of proposed line.	Real length of present line.	Real length of proposed line.	Equivalent length of present line.	Real length of proposed line.	Equivalent difference in miles.	Ratio of proposed to present line.	Equivalent length of present line.	Equivalent length of proposed line for 100 tons boats.	Equivalent difference in miles.	Ratio of proposed to present line.
Philadelphia to Pittsburg,	111	394	505	562	505	57	0.90	562	433	129	0.77
" Franklin,	41	460	501	628	501	127	0.89	628	430	198	0.70
" Kiskiminitas,	111	365	476	533	476	57	0.89	533	408	125	0.77
" Red Bank,	41	400	441	568	441	127	0.78	568	378	190	0.67
Middletown to Pittsburg,	69	294	363								
" Franklin,	1	360	359								

This shows the comparative cost of transportation, and does not take into account the constant loss from pilfering at the points of transhipments and change of hands.

Take the following calculations extracted from the proceedings of the Union canal convention, December 4, 1838, and furnished, as I have been informed, by a gentleman formerly one of our most distinguished engineers, and now familiar with the cost of transportation from his own personal experience with boating, to supply the iron works in which he is engaged. The extract will be given entire, as it contains some other matters that belong to the main question of the present communication.

"When, therefore, our central location in reference to the lakes at Erie and Cleaveland, to Pittsburg on the Ohio, and to the vast commodities of the mineral, agricultural, manufacturing, and lumber districts of the state is sufficiently estimated, it becomes apparent that the policy adopted in 1826, was founded in wisdom, and that the motives for speedily completing and extending our line of internal navigation, are powerful beyond those which can actuate any of our great competitors.

12. The practicability of graduating the capacity of the Union canal to the exigencies of the accumulated trade which a few years must bring to it at Middletown, from the various sources referred to, will scarcely remain an open proposition after the united testimony of Mr. Harris, and other distinguished engineers, shall be duly considered. Nor will the objection which has been urged against it as a navigation whose summit is supplied by means of reservoirs and steam engines, and therefore insufficient for an extensive business, remain unanswered if a moment's attention be given to similar works elsewhere, that are of established usefulness and great profit to the owners. Such canals are common in England; and how productive they are is shown by the astonishing advances in their stocks. The SOMERSET COAL CANAL is seventeen and a half miles long, with a lockage of one hundred and thirty-eight feet. Its stock per share was originally fifty pounds, and in 1821 it was worth one hundred and seventy pounds in market, and the same in 1834; and yet this canal is supplied on its upper level by steam engines. The STRAWBRIDGE CANAL, with its summit supplied by a reservoir; the WORCESTER AND BIRMINGHAM, by steam engine and reservoir; the Grantham canal, wholly supplied by reservoirs; the first five miles, the second twenty-nine miles, and the other thirty-three and one quarter miles long, pay in about the same proportion. The shares of the STAFFORD AND WORCESTER CANAL, were originally £140, and in 1821 had risen to £300, and in 1834 were £645. This work is forty-six and a half miles long, with a lockage of 394 feet, is supplied from two reservoirs, and yet divides thirty-six per cent. The first cost of shares in the ERE WASH CANAL, which is eleven and three quarter miles long, with a lockage of 108 feet and supplied from reservoirs, was £100, and has sold for £1,400, and divided seventy-two per cent. The

shares of the OXFORD CANAL, at first were £150; in 1821, were worth £670, and in 1834 £610, and divides thirty-two per cent; and yet the work has three reservoirs and one engine of one hundred horse power on its summit. There is good ground therefore for the prediction that the Union canal, being made the out-let for a vast coal region to tide water at two points, and in effect the eastern division of the Pennsylvania canal, its capacity being correspondent, will eventually not be behind the examples which have been enumerated.

The leading object of Governments in constructing works of internal improvement, is generally much more to cheapen intercommunication, than to bring revenue into the public Treasury. In this Commonwealth, the additional motive of populating large districts of wild, but first rate lands, by giving facilities for conveying surplus commodities to the public marts, and exchanging them for other necessaries or comforts of life, and thus increasing both the aggregate value of her real estate, and the amount of labor and products, is of decided weight and influence. Finally all those objects will be attained in this state; and the cheaper the means of intercourse be made, the nearer we approach the period when that shall be the case. It is therefore, advantageous, as well in reference to the project of widening the Union canal, as to our whole system of artificial navigation, to inquire into the relative expense of transportation on small and large canals."

13. With such view the following calculation, founded on the experience of practical boatmen, is submitted in tabular form; in which 210 days* are taken for the boating season, during which a boat may make nineteen trips of 113 miles. That distance is assumed, being as convenient as any other, for the purpose of the calculation. The average burden of boats on the Union canal is twenty-five tons, and on the Pennsylvania canal fifty-five tons, and therefore, an easy calculation shows that in nineteen trips, the small boat will carry but 475 tons, whilst the large boat will carry 1,045 tons. The following table shows the relative expense of large and small boats, during 210 days, or 19 trips, viz:

SMALL BOAT.

Two men 210 days, at 87½ per day,	$367 50
One boy, do do at 50 do	105 00
One horse 7½ months, at $11 00 per month,	82 50
One horse 4½ months, at 5 00 per month,	22 50
Depreciation of boat and horses with interest on first cost, &c.	95 00
Expenses on 475 tons,	$672 50

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* NOTE—The usual calculation is 240 days, or 8 months. Josiah White takes it at 270 days, or 9 months, (I presume from his experience on the Lehigh.)
B. A.

LARGE BOAT.

Three men 210 days at 87½ per day,	551 25
Two horses 7½ months at $11 00 per month,	165 00
Two horses 4½ months at 5 00 "	45 00
Depreciation on boats and horses with interest on first cost, &c.	120 00
Expenses on 1045 tons,	881 25

Then if 475 tons cost $672 50—tons 500,000 will cost	$707,894 73
And if 1045 " " 881 25—tons 500,000 will cost	421,650 71
Difference against the use of small boats on a trade of 500,000 tons,	$286,244 02

14. Extend this calculation to boats of 100 tons, supposing the locks to be 110 feet long in place of ninety feet. A lock of ninety feet will admit a boat of about eighty feet, and allowing five feet loss for the diminished bearings stem and stern; we get an average length seventy-five feet for the boat carrying as above, fifty tons or 0.733 tons per foot. In the same manner we find that an increase to fill a lock of 110 feet long will give us for the same cross section below the water line 69.67 tons, and when charged with one hundred tons, the area increased forty-four per cent., and consequently requiring eighty-eight per cent. of the strength of an extra horse to give them the same velocity. Therefore add the small balance and say this will equal the extra cost of a larger boat. No more hands are required, and we therefore get the following for a ONE HUNDRED TON BOAT:

3 men, 210 days, at 87½ cts. per day,	$551 25
3 horses, 7½ months, at $11 per month,	247 50
3 " 4½ " at $5 "	67 50
Depreciation on boats and horses and interest on first cost, &c.	160 00
Expense of 1900 tons,	$1,026 25

We have, therefore, the expense per ton, per mile for the different sized boats, as follows:

15.	For 25 ton boat,	$1.25
	For 55 "	0.733
	For 100 "	0.478

Josiah White gives the expense, with boats from fifty to sixty tons, at three-fourth cent, and 100 tons at half cent. Compare these two statements that are totally independent of each other, and not the result of collusion or compromise, and we find that the proportion, by the two, differ but $\frac{1}{44}$ of the expense of the largest as compared with the middle size, or one cent per ton in a hundred miles, and consequently agree with the above tables founded on the data furnished by the acting manager of the Lehigh canal company, and the transporters on the state works.

16. Again, canals constructed by private companies, are for the benefit of the stockholders who risk their funds in hopes of receiving a profit, and are consequently justified in charging toll in such manner as to make the work most profitable to themselves. If too high, they lose the trade. If too low, they are not paid in proportion to the benefit they confer on the public.

17. With the commonwealth the case is different. As soon as the canals pay interest on cost, the state is virtually out of debt, although the public documents may show many millions against her. The The object would then be to reduce the tolls as low as possible, so that there should be a small sinking fund, gradually to reduce the principal, for it is not the policy of a state to make a clear profit at the expense of her citizens, out of the tolls of her channels of communicaation, and thus drive away trade to some of her neighbors who have the power of carrying cheaper; since, by a reference to the table, it will be seen that the toll adds 200 per cent to the cost of transportation with large boats.

The results given above are not visionary matters, although they may create surprise. They are founded on experience. They do not depend upon my assertion. I have here given nothing of my own, except the calculations to show more distinctly the legitimate conclusions drawn from data, furnished by men who are eminently *practical*; and who, I presume, will not be charged with a propensity to "build castles in the air." Should any one doubt the accuracy of the statement, I would merely request him not to allow others to think for him, and depend upon vague assertions and unfounded hypothesis, but to procure the necessary facts from any one who is practically *acquainted* with the subject, and make his own calculations; and he will probably be surprised, as I have been, with the logical deductions from undoubted premises.

19. It may be well, in this place to remark, that the comparison between the two lines, the one by way of the Juniata, and the other by way of the West Branch is not made with the view of holding them up as rivals. We have more formidable competitors to contend with north and south; and the question is not whether the Juniata or the West Branch shall carry the trade, but whether we shall secure the transportation by furnishing a cheaper and a better route, or whether the extra expense and difficulties of the present line shall be allowed to drive the trade out of the state, and consequently our own citizens be deprived of this object of the industry, our own coffers lose the income that should be derived from the work already constructed, and our own commercial capital suffer for the benefit of others who have borne nothing of the burden of the improvements, and will hereafter bear none of the expenses of the state from which they draw their wealth.

20. There is another very important point of consideration. By the present interrupted communication, there is great irregularity as to time. The machinery is too complicated for an extensive trade. Ar-

ticles that belong to the same individual and that are despatched at the same time, become divided, sometimes damaged by the frequent changes, sometimes lost and when the owner receives the first parcel he cannot calculate upon the arrival of another that started at the same time. These frequent changes from hand to hand render it difficult to detect the offender, and hold out temptations for extensive robberies, such as were committed during the last season. The capacity of the portage is but a small part of that of the canal. I think about one seventh. There is a rigidity in the system that does not admit of changing from one point to another according to the change of trade with the season. The whole business must necessarily be monopolised by heavy capitalists who must have double sets of boats, double sets of cars, and five sets of agents. Their arrangements must be the same, whether the trade be light or brisk. They cannot pursue the course adopted by individuals who carry on the trade where the communication is uninterrupted between the two points, as for instance, between Philadelphia and any place east of the portage, by way of the Schuylkill and Union Canals; remain at home and attend to other business a part of the season, when there is little to do on the canals, and at another, when trade becomes brisk, transfer themselves, their hands and their horses from their farms to their boats. This is a very common thing on the route mentioned, and would extend with the line. The regular boatmen keep up the regular trade, and the transient men fall in when it is more profitable than their other business, whether in their fields or workshops. This extra expense is not therefore thrown upon the price of transportation, nor is the public burdened with the support of a number of idle boatmen, during the time when they have little to do, and the canal is consequently supplied with good citizens, in place of men whose idleness is apt to lead them into vice. Under the present arrangement, which must continue as long as the line is interrupted, a man who can save enough to buy a boat and horses, cannot in many places get an opportunity of exercising his industry, although he may not be able to find any other business that will answer as well, owing to want of information, or from some physical imperfection. A merchant cannot engage his neighbour, upon whose fidelity he can rely, to take down a boat of produce, meet it at the market, see his merchandise shipped—return home, and make his calculations, not only as to time but also be certain that every thing will come safely to hand, and all together. He must now incur an extra expense in the transportation of grain, since he cannot ship it in bulk, while articles that are large and heavy are excluded, from the difficulties of the frequent transhipments. As the trade increases the difficulties will increase in proportion, at least many of them.

21. Pennsylvania has entered the lists, as a generous rival with the states north and south of her. She has not pursued the selfish policy of refusing to her neighbours the extension of their works within her borders, when she might have drawn a line around her limits, and refused the admission of competitors. Time will show

that she loses nothing by this magnanimous policy. She not only holds a commanding position from her immense internal sources of wealth, But her geographical situation and natural facilities for the construction of the great national arteries, that give health and vigour to the young giant, are such that she may bid defiance to any injurious competition from north or south, and freely admit them to assist in carrying us onwards in the magnificent course of improvement. But natural advantages will be of no avail, unless improved. The tortcise won the race from the swift footed hare, who found to her sorrow that what she thought "time enough proved to be little enough." Let Pennsylvania apply the fable.

22. There is no intention in the preceding remarks to depreciate the worth of the present main line of communication. Although it has its defects and inconveniences, it is a noble work and will soon command a full share of trade from the business along its borders. In the immenco business on the Erie Canal of New York, the trade from a distance is scarcely felt among that which commences and terminates within herself.

23. We dare not reduce to figures the probable amount of tonnage that will in a few years arise from the intercourse with the great and growing country that is beyond us. Supposing it should be profitable to bring it over the present line, our own business would soon be embarrassed by it, and it is highly important for those along the present works to provide in time, another outlet for the surplus, or they will find their produce and merchandise shut up in their warehouses, and be obliged to seize an occasional opportunity to slip in a part between the articles belonging to other states, since, according to the invariable rule, those that come farthest have the preference. Without this advantage they would go elsewhere, and even with it the greater part of the distant trade will be forced off to other channels, rather than submit to the delay, uncertainty, and inconvenience of a communication crowded beyond its capacity. If on the Erie Canal of New York, we find at times a line of boats, half a mile in extent waiting for their turn to pass the locks, what can we expect with a route of *one seventh* the capacity. That another outlet can be made is certain, and it is hoped that the present communication will go far towards settling public opinion on this point.

24. Taking it for granted at present, that an entire water communication is practicable, I would earnestly press the importance of an increase of dimensions. Those who are opposed to an enlargement will find a strong support in the opinion of judge Wright as may be seen by a reference to his letter. Still with all deference to the best individual authority in the country, I can not give up my own opinion when supported by that of every other practical man with whom I have conversed or communicated on this subject.

With reference to this matter the following communication was transmitted to the board of canal commissioners at the time of its date.

FARRANDSVILLE, 24th June, 1838.

To the Board of Canal Commissioners of Pennsylvania.

GENTLEMEN:—

The time has arrived that I consider it my duty to propose a plan of improvement, which I have long thought would eventually be carried into effect.

It appears to me the wisest policy to suit our works to the end proposed rather than to go on in the beaten track without looking to the future, and thereby find that during their construction on one plan, the country has advanced so far as to require an entire change, and that a great portion of the original cost must be sacrificed in order to suit the works to the new condition of things. New York is about doing the latter in order to suit her canal to a distance that is but a fraction of what will be opened to Pennsylvania, when her thorough water communication is completed, and boats pass from the Mississippi without breaking bulk, as I am satisfied will be the case as soon as the necessary facilities are given.

The present is a propitious time. The Union canal company is ready to increase the capacity of their canal as soon as they can procure the funds, the Schuylkill navigation is ready to meet them. The state locks are to be doubled to Duncan's Island, and eventually to Northumberland. The canal is yet to be constructed from this place to the Kiskimminitas (and when that is finished the locks must be doubled to Pittsburg). I would therefore earnestly request the board to allow me to make the first step towards the improvement, and construct a canal capable of carrying boats of 100 tons, having locks of the same width as those below but 20 feet longer, making them 17 feet wide by 110 feet long, and depth of water 6 feet. This can be done without any great increase of cost, for the height of guard bank necessary to keep out the freshets will be such that only part will have to be raised to give the extra 2 feet depth of water, and the expense of the locks but slightly increased. The corps will commence in a few days to arrange the line with this view, at least so far that all the work now done shall be so much towards a final improvement and not require to be torn up when a change is to be made; and I feel confident that it will be done at no distant day. The plan that I should propose would be similar to that pursued on rail roads. Lay the foundation for a double track but put on single superstructure, or in our case, have the work constructed of the present size in all places where it can as well be done at any other time, but along the bluffs leave sufficient space for larger dimensions.

The Lehigh company have received the full benefit of their large canal. Their locks are 22 feet wide by 100 feet long, canal bottom 45 feet wide, and water 5 feet deep, and they carry 100 tons. I should propose 34 feet bottom, or even 32, but the larger the better.

Should the state with the magnificent prospect of a command of the western trade by the way of the Ohio, hesitate to do what the Lehigh company have done for their own local purposes? When we see what New York is doing, should we not take warning from her experience, and not run into the same difficulties that she has done? I hope the board will at least sanction an increase in the length of the lock to 110 feet in the chamber, and incurring the slight additional expense of placing the banks in such a position that they may hereafter be raised the extra two feet without the loss of what has already been done, and in that hope will proceed until ordered to the contrary by the board, and shall use my utmost endeavors to obtain the same arrangement on the Union and Schuylkill canals.

It would certainly be extravagance to lay out money in carrying through a plan that was correct for an interrupted trade but not for a thorough water communication, and that will require alteration as soon as the connexion is formed. The question is one for the board, not myself to decide. I express my opinion, and I have reflected much, although I have said but little on the subject, and shall be highly gratified if the board see the subject in the same light that I do, and order me to proceed.

A confidential letter of the same tenor was written to several individuals, and I had the gratification to find myself sustained by the highest authority, and in some instances where I expected opposition.

A desire was expressed to have it immediately before the public, but objected to on the grounds that it might become connected with the questions that were at that time agitating the commonwealth, and as in the case of the *National Observatory* in 1825, stand or fall not on its own merits, but according to the ascendency of party.

This matter was again presented to the board in the following communication.

25. FARRANDSVILLE July 25, 1838.

TO THADDEUS STEVENS, ESQ.

President of the Board of Canal Commissioners.

SIR:—With respect to the locks, I have made the followtng calculations of the extra expense, supposing their length to be increased 20 feet, and heighth 2 feet.

Taking the perch of stone at $4 50, cement $1 00 per perch of wall, timber 18 cents, plank 18 cents, concrete $2 00, we have 1 lock 6 feet, increased cost of extra length

But usual heighth,	$660 90	$660 90
7 of 8 feet lift	833 58	5,835 06
4 " 9 " "	961 12	3,844 48
1 " 9½ " "	1,032 08	1,032 08
4 " 10½ " "	1,172 56	4,690 24
1 guard lock		660 90
		16,723 66
Add ten per cent		1,672 37
		18,396 03

There are 18 locks, and consequently the expense will be a little over $1000 per lock.

As far as the work is concerned, the question of increase need not be decided until it becomes necessary to lay the bottom, since the only change would be an increase of 20 feet in the length of the chamber of the lock. The appropriation being small in proportion to the extent of the work, and plenty of room for its employment on the rock sections during the winter, the locks might perhaps be left until next spring. Should the length be increased it would require 112 perches per lock to raise the walls 2 feet. This at $5 50 per perch—$616 00, and extra timber say $34 00—$650 00 or for 17 locks $11,050 additional, add 10 per cent and the former amount of $18,396 03 and we have $30,551 03 to complete the work for boats of 100 tons as far as the locks are concerned. It would take some time to make out an estimate of the expense of raising the banks an extra 2 feet, to admit water 6 feet deep. But it would not be a large item, since our graded banks and deep cuts take off a great part of the distance, and would be ready for the extra depth, &c. &c.

The subject of enlargement was again submitted to the board as follows:

26. KITTANNING, 28th August, 1838.

To THADDEUS STEVENS, ESQ.

President of the Board of Canal Commissioners.

SIR:—I should be pleased to have the views of the Board, as to the plan upon which I am now laying out the Sinnemahoning Extension, West Branch Division, Pennsylvania Canal. Having received no directions to the contrary, I am now working by the rule that I previously adopted and mentioned in my communication, 24 June, founded upon the following considerations, exemplified by the accompanying diagram, showing the disproportion between locks 17 feet wide, and canal bottom 28 feet.

Supposing the boats to be constructed so as to allow 6 inches windage, in the locks, although upon some of our canals, but 2 inches are left, and never to come within less than 6 inches of bottom, although the work below Farrandsville, is calculated to allow the boats to run at bottom, also that the canal always retains its nominal width, which in fact it will not do, for one month after the water is let in, and we find that two boats cannot possibly pass each other, requiring 2 feet 2 inches, extra width, where the banks are of earth and slope 1½ to 1, and 3 feet 3 inches, where the berm side is of rock, cut down to the slope of 3 inches to the foot. This also allows the corner of the bottom of the boat to be rounded off, at a radius of one foot. If, however, two flat bottomed boats meet, if the boats be wider, if they run deeper, for instance when the level is low, or after the angle at the bottom fills up, the difficulty in either case is increased, and it is quite possible that they may all occur together and make a still greater difficulty or rather difference; for in either case, the canal would be as effectually stopped, as if one boat closed the whole passage. This arrangement is so much out of proportion, that I cannot imagine whence it was derived except that because the New York canal, was 28 feet bottom, and the Juniata canal 28 feet bottom, and in both cases the locks 15 feet and the canal found to be large enough, therefore, it must answer with locks 17 feet, and that this width has been retained without reflection, and perhaps also from the large sound of 40 feet water surface, that has led them astray as to the real capacity of the canal. Still such having been the practice, I did not wish to make a greater change than what I thought absolutely necessary, and consequently have given directions to make the canal 28 feet bottom, in all places where the future expense of increase will not materially exceed the present. But in all cases where the present would have to be ripped up, and the expense materially increased either by cutting deep into the face of a rock bluff, or by taking off the slope wall, cutting away the inside lining of the banks, forming the outside and relaying the wall, and also running the risk of bad banks from taking away the water tight lining. Then to make it 32 feet, or 4 feet wider, having given this width as a kind of compromise between 28 and 34, which I think should be the minimum size. But with 32 feet we will have nine inches to spare, if the boats allow six inches windage in the locks, and before the corner fills up, and when this occurs, I *suppose* that we will be able to *force* the boats past each other until the inconvenience leads to a further increase of width, &c."

27. To this letter an answer was received, which I must quote from memory, having neither a copy nor the original with me. I was allowed to go on with the canal of the size proposed, but the dimensions of the locks were laid over for consideration. It is worthy of remark, that the estimate of the Sinnemahoning Extension, is made out upon the supposition of a canal, 32 feet bottom, and leaving room for an increase of 2 feet in the height of the banks. The work is also now advancing upon this plan, while the size of the locks has not yet been definitively settled.

Having thus given "all the information relative to the expediency," that suggests itself at present in answer to the call, that is more comprehensive than was anticipated, the next point is the

28 PRACTICABILITY.

On this subject the following answers to the annexed circular will be read with interest, showing as they do the opinions of those in whom the public is accustomed to place confidence.

29. It must be remarked that none of the writers mean to say positively either that the plan might not be improved, or that we will have a supply on the proposed summit, for this cannot be *known* without a personal examination of the district. Each letter may be considered the general substance of a report that the writer would make, should he find the facts as stated. They therefore stand upon the same ground as the report formerly made on this summit. The data

from which the former conclusives were drawn, were correct as far as they went, but did not contain a full account of the resources. The data for the letters were obtained by extending the former work, and ascertaining that the *most important* parts had been *omitted*.

With respect to the statements made in my report, there is no chance of a material error so as to affect the result in the slightest degree, except in point of expense in the dam.

30. Had these gentlemen who have answered the circular held commissions as consulting engineers, these letters with a little change of form, would in reality have been reports, and cost the commonwealth thousands of dollars. The same process of consultation is frequently pursued. While acting in connexion with Canvass White both as his assistant, and when he was consulting engineer, (but as my preceptor, whose word for me was law,) I gave to him the facts and my own opinions in writing, he drew his conclusions and the work progressed accordingly, although he was hundreds of miles distant, and conseqently in the same relative position as the gentlemen who have favored me with their opinions.

31. That which costs us nothing is sometimes lightly valued, and the knowledge that these gentlemen have as a personal favour to myself in sustaining a great national work, liberally given their views, without commissions or expectation of consulting fees, and that the whole matter has not cost the commonwealth a copper, may with some diminish the importance that would otherwise have been attached to it. Should the legislature see proper to assume the position that I took, and ask these gentlemen their opinions, they would then receive more formal communications, at greater length and dressed up with more care, but the sum and substance would be the same, and the result thence drawn, that from the universal conclusions of all who have expressed an opinion, there would be an abundant supply of water, and that conclusion modified in only two cases by the proposition to test it practically before the work was commenced.

32. If therefore confidence be placed in my statement of facts, (in which I cannot be mistaken, and which I can easily prove if reqired from the notes alone.) These letters will have the same credit as *reports* of the individuals after having examined the country, and ascertained the statement to be correct, and would therefore settle the qestion as to practicability.

It being a matter of indifference which comes first, the letters will be given in alphabetical order.

33. CIRCULAR.

FARRANDSVILLE, 5TH OCTOCER, 1838.

DEAR SIR:—I wish to be prepared with the opinions of the different engineers of established reputation, and of other individuals of my acquaintance who are familiar with such questions, respecting the supply of water for the proposed canal from the West Branch of the Susquehanna to the Allegheny river. I should therefore be much obliged to you if you would give me your conclusions, drawn from the following facts, detailed in my report to the canal commissioners of Pennsylvania, read in Senate, 1st March, 1837, and for the accuracy of which I hold myself responsible.

I have not the least doubt myself, but I wish to leave no doubt on the minds of others. If you think differently I wish you would say so freely, as I desire your real opinion. Also, whether you agree with me in the confidence that we can command an abundant supply for locks, 110 by 17, and water in the canal 6 feet deep, 34 feet bottom.

The following are the facts shown in the report. There are 14 miles to be supplied from the summit, including 10 miles of reservoir, and 1 mile of tunnel. We can construct a reservoir of an average area 3 square miles, useful depth 20 feet, and extreme depth at the dam 40 feet, which could be easily increased to any extent desired to meet the drainage. Basin drained 80 square miles, 9 inches per annum fill the reservoir. Average rain in Lebanon (the nearest known point) for the last 7 years, 40.46 inches, greatest 44.78 and least 34.49; therefore 26 per cent of least amount fill the reservoir. Can commence the season with full reservoir, and as it is drawn down, leave room for intermediate rains, supposing more than 9 inches to be drained per annum. The country is composed of steep ridges in horizontal strata of coal, clay-slate, &c. almost water tight: few springs; discharging the water very suddenly, and then drying up (and I think ⅔ will flow off, but have estimated but 26 per cent.) A drift, say 6 by 6, and 5 miles long, at an average depth of 50 feet below the surface of the ground, would bring the waters of Little Toby, from present surface 35 feet above bottom of canal. Drainage of Little Toby 150 square miles, and suitable for reservoirs. Can thence extend an open feeder 20 miles and bring in the natural flow of Clarion river, the main supply of the Allegheny in dry seasons.

Calculations:—Reservoirs 3 square miles, 20 feet deep, equal to 1,672,704,000 cubic feet, 14 miles at 50 cubic feet per mile per minute loss, equal to 241,920,000 cubic feet annum. One lock fall every 2¼ minutes 15 by 90, and 5 feet lift, equal to 1,036,800,000 per annum of 240 days, total loss and lockage 1,278,720,000, leaving surplus 493,894,000, or nearly ¼ of the whole. This is only from 80 square miles at 9 inches per annum, while we have an extra 20 miles on the eastern side of the tunnel, 150 square miles on Little Toby and the Clarion river, at 20 miles distance.

Wm. Lehman Esq. Resident Engineer of the Union Canal, under date of 28th Sept. 1838, writes thus.

"At no time this year was the summit level of the Union Canal so low but that we could carry boats with 20 tons with ease. I am now better satisfied than ever that the waters of the Union Canal are fully sufficient for wide locks and wide canal. Although the season has been so dry, yet the aid of another steam engine at the water works on the Sivatara would have kept the summit in first rate order, and it would have saved the navigation of the reservoir which has been too low for boating since the first week in this month. The late rains are bringing the dam np again."

Union Canal 11 miles (note, Mr Lehman in his letter says 18 miles) supplied from summit, 24 feet bottom, 4 feet deep, locks near summit 4½ feet lift, 8.50 by 75 feet area. Reservoir 500 acres after deducting pond at head, not drawn down. Bottom of channel 14 feet below crest of dam, or 10 feet allowed for navigation. Water passes from reservoir 11 miles, and there works 3 water wheels and supplies one steam engine 120 horse power. Only get abuut $\frac{1}{6}$ into the summit 96 feet high, the rest being lost as water power and enters the canal below. Our proposed reservoir would be more than 4 times as large, and *all* the water could be used, besides our extra reservoirs all *flowing* into the summit.

ANSWERS.*

34. MAUCH CHUNK, October 21, 1838.

BENJ. AYCRIGG, ESQ.

Dear Sir :—Yours of the 5th inst. was not received until a short time since, owing to my having been absent. From the description of the country on the summit of the proposed canal between the Susquehanna and Allegheny rivers, and facts relative to the feasibility of constructing reservoirs and feeders, as detailed in your letter. I do not hesitate to say, that I fully concur with you in the belief than an abundant supply of water can be had, to feed a canal of the dimensions you propose, and do the most extensive business.

I observe that you have allowed but 50 feet per mile per minute to supply the canal. Unless the location and soil is unusually favorable, I am disposed to think that it will prove not to be enough. In all the canals which I have had any thing to do with, I have uniformly found the expense of water to be much more than that amount. The first year on the Delaware and Raritan canal, it required about 125 cubic yards [feet?] per mile per minute—the second year about 100 feet The main canal passes over unusually favorable ground for the retention of water; the feeder is not as favorable—the soil is quite porous, take the whole, I think it a fair average. A short canal about six miles in length on the Connecticut river above Hartford, required the first season 150 feet. I have not had an opportunity to gauge the water since, therefore cannot say what it now requires. An attempt was once made to ascertain how much the Morris canal required, but owing to the irregularity of their apparatus, nothing satisfactory was obtained. But if it should prove that fifty feet is not enough, and should require 100, you still have a large surplus, therefore any doubts on the subject must vanish.

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*That there may be no doubt at the present or any future time, when the public is prepared for the improvement, and the question comes to be seriously agitated. I send the original letters with such parts as do not belong to the present question, erased. As they are personal favours to myself, I desire that they may be returned to me after copies are secured.

Yours very respectfully,

E. A. DOUGLASS.

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35. WILLIAMSPORT, Oct. 24, 1838.

SIR :—About a year before you commenced the survey to ascertain if it were practicable to connect the West Branch of the Susquehanna by canal with the Allegheny, I wrote to Josiah White on the subject, and expressed a belief that it could be effected.

The data upon which I founded my calculations, were statements from Mr. Wilson as to the extent of country that would be drained into reservoirs and levels taken by him on both sides of the summit. Taking, therefore, one sixth of the whole quantity of water that would fall on the surface drained as directly applicable, I considered the quantity ample, at least for a trade, equal to the capacity of the Juniata route.

You estimate nine inches of what would fall as supposed to be directly applicable. My estimate would be about six inches, and I think it full, as great allowance should be made for local circumstances, where the extent of surface to be drained is so very remote from the reservoirs.*

Your estimate is also made for boats [locks ?] 15 feet by 90. If I recollect rightly, I proposed that the locks should be 180 feet by 17 with an extra set of gates similar to those at Farrandsville, so that the one half could be used for boats of the ordinary size, and in time, if the plan of doubling the chambers in a line were adopted, boats carrying from 120 to 150 tons would be found more advantageous, and economize water at the summit to a greater degree in proportion to the amount of tonage passed, than boats carrying from 30 to 60 tons.

With the supply that can be broght from Toby's creek in addition to the other, it would appear that a doubt could hardly arise, yet before the commonwealth undertakes a work of such magnitude, it would be well to ascertain beyond a shadow of doubt the exact quantity of water that could be relied on. Would it not be a good plan to appoint persons for a year to gauge frequently all the principal channels by which the drainage is conveyed to the sites of the reservoir at a point where they would intersect them, and found a calculation upon that supply alone, as no local circumstances would then exist except within the bounds of the reservoirs, for evaporation a safe calculation would be the depth when full, absorption would cease in time, and leakage be prevented, indeed the supply that would flow into the reservoirs, beside that through the channels, would balance absorption and leakage.

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* NOTE--Not over five or six miles at farthest. Mr. F. is not answerable for this erroneous supposition since it was not mentioned in the circular, and he has drawn the conclusion from the plan of feeding, formerly proposed, which is quite different from the present. B. A.

Excuse me for not replying sooner, as I am at present much engaged on the line. In haste,

ROBT. FARIES.

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36. LEBANON, Nov. 28, 1838.

B. AYCRIGG, Esq.
Civil Engineer.

DEAR SIR—Your letter of the 21st instant has just been received. If I am not mistaken, the data furnished by you in regard to the supply of water, is this, the average area of the reservoir three square miles. Basin drained eighty square miles, and that nine inches drainage per annum will fill the reservoir. Canal to be supplied fourteen miles inclusive of the summit level. From such data I have no doubt but an abundant supply of water is at command to supply any amount of business that may be done through one set of locks fifteen by ninety feet, with five feet lift.

Capacity of reservoir = 1,672,704,000 cubic feet; fourteen miles canal at fifty cubic feet per mile per minute, leakage and evaporation, loss = 241,920,000 cubic feet per annum. One lock full in 2¼ minutes, fifteen by ninety and five feet lift = 1,036,800,000 per annum of 240 days; leaving a surplus of 493,894,000, or nearly one-fourth of the whole.

From some interesting examinations made by John B. Jervis, Esq., chief engineer on the Chenango canal, N. Y., it appears that the drainage of the year was found to be 0,523, or over half the falling water. In Madison Brook valley, where the surrounding country consisted principally of easy slopes, and the usual proportion of cultivated land, the drainage from June to October, 1835, was 0,246 of the rain which fell.

Yours respectfully,
SIMEON GUILFORD.

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37 CHAMBERSBURG, PA., Nov. 26, 1838

DEAR SIR.—Your favor of the 5th October was only received a few days ago, having been sent after me to different places as far as Greensburg and back to this place.

You ask me therein for the "conclusions" drawn from the facts you state, and whether I agree with you in the confidence that you command an abundant supply of water on your Allegheny summit, with Locks 110 by 17 feet, and water in the canal 6 feet deep by 34 feet bottom—14 miles to be supplied.

I fear that the delay occasioned by receiving your query and the limited time now at my command to investigate the subject, will render any reply of little value to you. The calculations however, which you have made in regard to the supply of water to be collected into the reservoirs you design, appear to be correct; and your experience in this matter has no doubt enabled you to take every advantage of the locality, with which I regret to be totally unacquainted.

The method of supplying a canal during the *dry season* of the year, with water entirely drawn from reservoirs, is by no means novel. In the case you speak of, a sufficiency appears to be at command for *the whole year.* The supply intended to be collected from rains of the surface you can drain, appears equally moderate, if too much is not lost by leakage and evaporation in the reservoir.—The most remarkable instance I have noticed of water collected in this manner from drainage, is described in a report on the Shaw water works in Scotland. The great reservoir located there by Mr. Thom, covers 296 acres, drains 3600 acres, has a depth of 48 feet, and contains 284,424,172 cubic feet water. The annual amount of rain in that country, is said to be less than in this, but about 60 per cent. of the rain must at all events have been collected into this reservoir.

In the autumn of 1834, Mr. E. H. Gill and myself were engaged by the Sandy and Beaver canal company to examine the quantity of of water that might be rendered available on their summit level. During our engagement there, we extended our examination to the Licking summit of the Ohio canal, then in operation—this portion of the canal was supplied for upwards of 20 miles entirely from a reservoir, and notwithstanding the streams which usually flow into it it had for many weeks been dry, this reservoir had been able to furnish an ample supply of water for the exigencies of the trade.—That reservoir, when full, covers 2,750 acres, to an available average depth of 67 inches—of this 31 inches had been drawn off previous to the 1st October, and 36 inches remained. The surface was probably reduced about 4[illegible]0 acres in extent, and by gauging, we found that 1,329 cubic feet per minute was discharged into the canal at that time. The circumstance that the trees had not been cut down and removed from the surface of the ground occupied as reservoir, and continually fell down in the water, occupying the space that the water ought to have, operated materially against making any calculation of the actual quantity of water in the basin.

The summit of the Chesapeake & Ohio canal, as examined by Gen. Bernard, was, if I recollect right, also to have been supplied by water from reservoirs alone. These canals and the Union canal are so near to your line that it is likely people interested in the subject may examine, or at least inquire into them. It appears, however, to me very important that the streams which you intend to use in charging the reservoir, should be constantly and of course carefully gauged through every day in the year, and for as *many* as could be thus recorded before entire confidence could be placed on their supply. I would also be interesting to know from survey, the exact area drained, and the annual quantity of rain which fell on this surface. The quantity of water might be thus ascertained with accuracy; the loss by absorption and evaporation in proportion to the quantity that would be available, would thus be established, and no doubt could exist in any persons mind as to an ample and sure supply. I have often thought on this subject, and regretted that such an experiment, at least, should have been neglected so long, when the result will be useful in a very great many ways of application, as for lands, mill power, supply to towns, &c.

I regret that I must leave this interesting subject to you in so hasty a manner. The limits of a letter can only hint as to what should be expressed more fully and more maturely digested. I hope, however, that you will at your leisure favor me with any observations that may seem interesting, and that you will excuse that I only can offer such common place remarks.

Yours, very respectfully,
HOTHER HAGE.

B. AYCRIGG, Esq. Civil Engineer.

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38 LEBANON, Nov. 26th, 1838.

B. AYCRIGG, Esq.

DEAR SIR.—I have to acknowledge the recept of your letters of October 5, and November 2, and will endeavor to say something in regard to a "supply of water for the proposed canal from the west branch of the Susquehanna to the Allegheny river."

Without entering into any particular details, I will merely state, that I have carefully examined into the resources you have, as laid down in your letter of 5th of October, and compared them with the available means for the supplying of the summit level on the Union canal, and find that you will have five fold the amount of water at command in the reservoir, which is to form a part of your navigation, to what the summit of the Union canal has, while you will have but 14 miles of canal to supply, including 10 miles of reservoir and one mile of tunnel, when the Union Canal has to be supplied for near 18 miles* with only one-fifth part of the means that you have, and this without taking into view the great additional amount of water you may gain by taking in the Little Toby and Clarion river. A very important advantage you have too over the summit on Union Canal, which is, that your drainage is much more extensive, and it is all directly into your summit, which is not the case on the summit of the Union canal. We never experienced so dry a season on the Union canal as what the last was, and yet with the very small proportion of means resorted to for keeping up the navigation, it was highly gratifying to hear from all the boatmen, that they got along through the Union canal with much greater ease than what they did either on the state or Schuylkill canals. I have no hesitation in saying, that the means you have at command for supplying your summit will be fully sufficient, and in regard to your having locks 110 by 17 feet in the chamber, they will be more economical in the use of water than smaller locks, as large locks will, at all times pass a much greater amount of tonage in proportion to the water expended, than what smaller locks will do. The size of your canal too, 34 feet bottom, 6 feet deep, is right.

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* I think that Mr. Lehman has inadvertently called the distance supplied from the summit 18 miles. We have been accustomed to call it 11 and 15 miles, there being 11 miles fully and 4 partially supplied, and perhaps a fair average would be about 12½ miles. B. A.

In regard to the enquiry made in your letter of the 2nd inst., relative to " notes" from "time to time," to be taken by Mr. ——— of "the height of water flowing over the great dam, and when below the crest, to note the height and also the amount of opening in the sluices." All this, as you say, would be important, I would give you with a great deal of pleasure if I could get it out of Mr. ———. He commenced with keeping notes, but did not carry them through.*

Very respectfully,
Yours, &c.
W. LEHMAN.

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39. COLUMBIA, NOVEMBER 12, 1838.

DEAR SIR:—Your letter of the 5th ultimo was duly received. In reply to your queries respecting the practicability of supplying a canal, under the circumstances therein mentioned, allow me to submit the following argument:

Your proposed reservoir of three square miles area and twenty feet deep will contain upwards of 1600 millions of cubic feet of water, it is to be filled by the drainage of a basin of eighty square miles, upon which there falls annually not less than thirty-four inches of rain, making a total of more than 6,000 millions cubic feet of water, which will allow nearly three-fourths the whole quantity for absorption and leakage. Considering the nature of the soil composed of clay, clay slate, &c. this appears to be a very liberal allowance. I have therefore no doubt of the practicability of filling the reservoir from this source.

Now to ascertain whether this supply will be sufficient for the canal of the required dimensions we must estimate. First, the quantity required to fill the locks while in constant use during the working season, say of eight months or two hundred and forty days. Secondly, the quantity lost by leakage along the whole length of canal during the same time. Thirdly, the loss by evaporation from both reservoir and canal, during the longest probable drought, say four months.

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*NOTE.—As soon as the examination was finished and I knew the character of the supply for our summit, I requested Mr. Lehman to procure these notes for me, since I know that a vast amount of water runs to waste over the dam in the Swatara. B. A.

In calculating the first of these quantities, I have taken the largest dimensions given in your letter, to wit: 110 by 17, and 6 feet lift.

For the second item, I perceive you have made an allowance of 50 cubic feet per mile per minute, which is sufficient to empty the whole canal in thirty-six days. Instances are recorded, such as the canal De Narbonne, which emptied itself in twenty-one days, and the feeders of the Languedoc canal in twelve days, but these appear to be extraordinary cases. Mahan's civil engineer gives about ten feet per mile per minute for a new canal, which is perhaps the other extreme.

For such soil as you descibe, I should suppose your allowance a very fair one.

For the third item I have taken the authority of Smeaton, whose data are the most liberal I can find on record, he says a four months drought will not lower a reservoir by evaporation more than 10 inches.

Here follows the calculation from the above data.

Contents of reservoir 3 square miles, 20 feet deep,		1,672,704,000
On lock 110×17×6 filled every 3 minutes, per year of 240 days	1,282,544,000	
Leakage 14 miles, 50 cubic feet per m. per m.	241,920,000	
Evaporation during 4 months, &c.	72,790,000	1,597,254,000
Surplus,		75,450,000

When we consider that the season can always be commenced with a full reservoir and that no allowance is made above for intermediate rains, and that the estimate for filling the locks evey 3 minutes, is more than four times what would be required by the present trade of the Pennsylvania canal, I think no doubt can be entertained of the sufficiency of supply from the reservoir alone, and should the trade ever increase to such an amount, as to render a further supply necessary, the profits arising from such an increase of trade, will be sufficient to justify a resort to your proposed feeder, drawn from Toby's creek and Clarion river.

Respectfully yours,
S. W. MIFFLIN, C. E.

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40. PHILADELPHIA, Nov. 30, 1838.

B. Aycrigg, Esq.

Dear Sir:—Your letter dated October 5th, but post marked Nov. 22, was received by me three days since, and according to your request, I have examined your data and calculations and very frankly give you the results.

From what you say of the country I am satisfied that enough water can be had for the supply of the canal you contemplate, without resorting to Little Toby, provided you increase the dimensions of your reservoir, or add another of a similar kind and take into it the drainage of the twenty square miles east of your tunnel.

I am not satisfied with the results to which you have arrived, and therefore give my calculation below.

	cubic feet.
1. Amount required to fill the prism of canal in spring, 14 miles long, 4 feet deep, 28 feet bottom,	10,053,120
2. Leakage, soakage and evaporation 100 cubic feet per mile per minute, same distance,	483,840,000
3. Lockage as in your estimate,	1,036,800,000
4. Evaporation on reservoir, 3 square miles 3 feet per annum,	250,905,600
5. Filtration of reservoir equal to 6 feet per annum same surface,	501,811,200
Total,	2,283,409,920

This amount which is 610,705,920 cubic feet more than the whole content of your reservoir, is as little as I would be willing to calculate upon to feed a canal under similar circumstances. I think, however, that you have underrated the amount which would flow into the reservoir, and that twelve inches upon the whole extent drained is a reasonable calculation.

	cubic feet.
This upon 80 square miles would be	2,230,272,000
And upon the 20 additional at the eastern end,	557,568,000
Total,	2,787,840,000

Which, if sites for storing it can be had, I consider an ample supply, without there being any occasion for a resort to so formidable a feeder as would be required, in order to bring the waters of Little Toby into your summit.

Of course I do not pretend to give an opinion on the subject of reservoir arrangements; for without examining the ground, it would be impossible to form a judgment on the propriety of any particular plan; nor do I wish to be understood as expressing an opinion that a water communication by the route of the Sinnemahoning, is advisable, for even were the question of water set at rest conclusively, and an ample supply demonstrated to exist, I think the other difficulties and objections to be exceedingly great.

I am very truly your friend.

EDWARD MILLER.

P. S. On looking over the above it has occurred to me, that the amount of trade which you have calculated upon, is so exceedingly great, that I can hardly suppose it possible that it can be anticipated during the present age. The item of lockage water therefore, which is by far the largest in your estimate, might be reduced considerably, and probably to a sufficient extent to make the single reservoir which you have proposed, sufficient, without resorting to the eastern reservoir of which I have spoken. E. M.

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41. COLUMBIA COLLEGE, (N. Y.) Oct. 20, 1838.

SIR:—I have examined the calculations and circumstances which you have communicated to me, in relation to the supply of water for the proposed canal from the West Branch of the Susquehanna to the Allegheny river. I do not consider that there need be the least doubt that the proposed reservoir, receiving the drainage of 80 square miles of a country, such as you describe it would suffice for the supply of the canal for many years after it shall be constructed. It is, however, to be taken into account, that the clearing and cultivation which will probably follow the completion of a navigation will produce a change in the flow of the surface waters. It is, therefore well, that you have included in your plan of supply, the use of the waters of the Little Toby and Clarion rivers. When these shall be added to the supply of the reservoir, it may be considered as certain, that a canal of the largest dimensions and carrying its full amount of trade, may be supplied without risk of failure.

I am sir respectfully,
Your ob't servant,
JAS. RENWICK.

COL. B. AYCRIGG,
One of the Chief Engineers of the state of Pennsylvania.

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42. CATTAWISSA, Columbia co. Pa. October 26th, 1838.

B. AYCRIGG, ESQ.
Civil Engineer,

DEAR SIR:—Having considered the case stated in your letter of the 5th inst. my opinion is that you have proved the practicability of commanding a sufficient supply of water for the summit level, of the proposed canal between the West Branch of the Susquehanna and the Allegheny river. I think that the loss by soakage and evaporation from the surface of the reservoir will exceed your estimate; but that this will be much more than counterbalanced, by your being able to command at least twelve inches of water from the surface drained, instead of nine inches which you have estimated. With a reservoir capable of storing up twelve inches of drainage, from a surface of eighty square miles, and with a feeder from the little Toby, I think that without any aid from the Clarion river, you will have water enough for "a canal of 34 feet bottom, and six feet deep, with locks 110 by 17 feet," and it is my decided opinion, that a canal of dimensions equal to these, ought to be constructed.

Yours, very truly.

S. W. ROBERTS,
Civil Engineer.

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43 PITTSBURG Nov. 30th 1838.

B. AYCRIGG, ESQ.
Civil Engineer.

DEAR SIR:—Various engagements have prevented me from replying at an earlier date to your letter of October 5th, I now do so with great pleasure. You wish me to give my conclusions drawn from the facts contained in your "report to the canal commissioners of Pennsylvania, read in Senate March 1st 1837, respecting the supply of water for the proposed canal, from the West Branch of the Susquehanna to the Allegheny river," and also, "to state whether I agree with you in the confidence, that an abundant supply of water can be commanded for a canal, with locks 110 by 17 feet, water in the canal 6 feet deep, 34 feet bottom." It will not be necessary here to recapitulate the facts contained in your letter. Suffice it to say, (for the present,) that I have carefully examined all the calculations based upon them, and found them to be correct.

I will now proceed to give some general views, preliminary to the expression of an opinion in the case, as stated in your letter.

Having been engaged for several years in the location and construction of public works on and near the Allegheny mountains, and along streams on the eastern and western sides, I have had excellent opportunities of becoming familiar with the general features of the country, its soil and climate, and the geological position of its rocks. I have long entertained the belief and heretofore expressed the opinion, that the western slopes of the Allegheny, present more and better sites for extensive reservoirs than any region in the United States. It is a country peculiarly adapted to reservoir purposes.

The ridges being generally steep, and the strata of coal, clay, clay-slate &c, horizontal, it naturally follows that a very large proportion of the rains which fall, must be discharged suddenly into the rivulets and creeks, which with nearly equal rapidity empty themselves into the main branches. Frequent evidence of this is seen in the sudden and sometimes devastating floods which occur in the streams draining the western slopes of the mountain, as compared with those draining the eastern side, Immediately after a general rain upon the mountain, it may be noticed, almost invariably, that the western streams are very much the fullest, and yet, after long continued dry weather, exactly the reverse is the case. The difference may, I think, be attributed to the various strata of rock, slate &c. On the eastern side, it is well known, that the strata are inclined or dip at an angle of about 30 degrees *towards* the mountain. The rain consequently percolates between the strata instead of running immediately off into the ravines, as in the case of the horizontal strata, and appears perhaps after a long interval at some lower level. Thus without the aid of artificial reservoirs a given quantity of rain on the eastern side would be more effective in supplying a canal, than a like quantity on the western side. I refer to these local features, because, I think they contain in themselves the clearest and strongest arguments in favor of the construction of artificial reservoirs, as the only *permanent* sources of supply for any canal depending upon the western tributaries of the Allegheny river.

It is a matter of public notoriety, that the western division of the Pennsylvania canal, has suffered from low water during the latter part of the summer for several years. This annoyance and real public calamity, would have been entirely avoided, if the reservoir which was proposed and located up the Stony creek, under the direction of Sylvester Welch, Esq. had been constructed at the time recommended, viz: in 1835. It must be resorted to at an early day, or the works of Pennsylvania will suffer grievously in public estimation.

I have freely given you these views to show my decided conviction of the expediency of preparing at the *commencement*, for reservoir supplies, in the very case to which you have called my attention.

There are, I believe, but two instances in this country, from which practical data as to the utility of reservoirs are to be obtained. The Union canal, in this state, and the Ohio canal. I am well acquainted with the details of the first, having as you know, been an assistant upon it for some time. I will, however, take the liberty of repeating the facts respecting it, which are contained in your letter. "Eleven miles supplied from summit—24 feet bottom, 4 feet deep. Locks near summit 4½ feet lift, 8½ by 75 feet area. Reservoir 500 acres after deducting pond of 220 acres at upper end not drawn down, bottom of channel 14 feet below crest of dam or 10 feet allowed for navigation. Water passes from reservoir 11 miles, and then works 3 water wheels, and supplies one steam engine 120 horse power. Only get about one-sixth into the summit, 96 feet high, the rest being lost as water power, and enters the canal below." With this disadvantageous arrangement, by which $\frac{5}{6}$ of the water is *consumed as power* required to force up the balance to the summit level, it has been found to answer admirably for ten years, without having once failed. It must be recollected too, that the summit level lies upon a porous, limestone country, where it is almost impossible to make a canal water tight. The leakage is therefore rather above the common average. Here then is a reservoir only one-fourth the size of that proposed on the West Branch route, (only one-sixth of whose supply has been available at the summit,) fully successful.

The Licking summit of the Ohio canal as I have been informed, is supplied from a reservoir draining only from 30 to 40 miles of country, supplying near 30 miles of the summit and its dependent levels with water, and, during the dry season, about forty-four miles of canal. The loss on that canal by leakage and evaporation, according to the estimate of E. H. Gill, Esq., civil engineer, is but *twenty-five* cubic feet per minute (per mile). On the Languedoc canal, according to Gen. Bernard, the loss by evaporation and leakage, averaged less than 19 cubic feet per mile per minute. In estimating the loss in the West Branch route, from the same causes; at 50 cubic feet, I have not the slightest doubt that you have been abundantly cautious.

My calculations, respecting the reservoir you have proposed, would be as follows, viz: Reservoir 3 square miles, twenty feet deep, *one and a half* times filled=2,709,056,000 cubic feet, 14 miles canal, at 50 cubic feet per mile per minute, loss=241,920,000 cubic feet per annum (of 240 days.) For locks 110 by 17 feet, say 6 feet lift, require 11,220 cubic feet per lock full. Allowing one boat to pass every five minutes, or 288 boats per 24 hours, the quantity of water required for lockage would be 3,231,360 cubic feet per day or 775,526,400 cubic feet per annum. This added to 241,920,000, the loss by evaporation and leakage would make 1,017,446,400 cubic feet, total consumption per annum. Which deducted from 2,709,056,000 cubic feet, estimated supply from reservoir would leave 1,691,609,600 surplus, or somewhat more than enough to fill the reservoir. It should not be inferred from the proceeding calculations, that the reservoir would be full at the close of the navigation, because, much of what appears in the calculation as surplus, would doubtless run to waste from the reservoir in the spring of the year.

But look at the immense amount of trade which has been estimated as requiring 1,017,446 400 cubic feet of water, 288 boats per day or 69,120 per annum. Now supposing these boats to carry but 30 tons each, it would amount to the enormous sum of two million and seventy three thousand and six hundred tons, which I take to be rather more than will probably pass that way in any one year, for two hundred years to come. In conclusion, I can only add that I am thoroughly convinced, that upon the plans you have proposed, you will have a super-abundance of water for all the legitimate purposes of a canal of almost any size.

Yours respectfully,

W. MILNOR ROBERTS.

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44. BALTIMORE, November 26th, 1838.

MY DEAR SIR:—I may but express my opinion, on the subject of the practicability of a canal over the mountains, at head of the West Branch of Susquehanna, by a report of mine, on a similar subject, which I enclose and send you.

I will add, that from the facts disclosed in your report, and my personal knowledge of the country in question, I have no hesitation in expressing the opinion, that a canal of largest dimensions over the mountains, if judiciously located and constructed, with its accompanying reservoirs, feeders, &c. is practicable, with an abundant supply of water for an active trade. The State of Pennsylvania committed a great mistake, in not selecting this route, when devising her system of Internal improvements; which it is not too late, however, to remedy.

Very truly yours,
ISAAC TRIMBLE.

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45. Lambertville, N. J. Nov. 16th, 1838.

Benjamin Aycrigg, Esq.

Dear Sir:—You ask my opinion on the following case. A canal of fourteen miles in length is to be supplied with water. Besides the leakage and waste a lock full every 2¼ minutes may possibly be required for 240 days in the year. The locks being 90 by 15 in the chamber and of 5 feet lift, require at this rate 1,036,800,000 cubic feet of water per year. A basin of very hilly country containing 80 square miles, is all drained into a reservoir of 3 square miles average area, and of 20 feet useful depth. This country is principally a clay slate, in horizontal strata, almost water tight. Will the drainage of this basin collected in the reservoir supply the canal?

A canal of the dimensions common in Pennsylvania, unless the bed, the materials, or the execution of the work be very bad, requires from 30 to 60 cubic feet of water per mile per minute, besides the lockage water—14 miles at 60 cubic feet per mile per minute, would require 290,304,000 cubic feet per year of 240 days. This added to the quantity that may possibly be required for lockage, makes 1,327,104,000. Add for filling the canal, accidents, loss in winter, &c., 80,000,000, making in all 1,407.104,000 cubic feet per year. I have no doubt that this quantity is abundant, unless there is something in the soil very different from what is to be expected in the country above described. I have calculated the ordinary waste in canals, but where a scarcity of water is apprehended, much of this waste can be prevented by additional care and expense in the construction of the work.

A reservoir of the dimensions mentioned, would contain 1,672.704,000 cubic feet of water. The circumstances of the case, do not require that the evaporation should be deducted from this quantity as it would not exceed the water falling directly upon it. If the reservoir should receive this quantity of water during the year, whether all at once, at a few times as in hard storms, or gradually (the manner being immaterial on account of the great size of the reservoir) there would be a surplus after supplying the demand as estimated above.

In Hunterdon county New Jersey, the rock is a red shale of various hardness, dipping at an inclination of about twenty degrees. From observations and calculations upon the streams in this county, I think that about one third of the water that falls in a shower upon any given space, is discharged through the streams draining that space in about 6 hours. The horizontal clay slate would probably absorb less water than the inclined shale. So that in the country described, 27 inches of rain falling upon 80 square miles would fill the reservoir, and probably much more than fill it. The usual quantity of rain being 40 inches instead of 27 inches per year, makes the calculation that the reservoir will be filled a safe one.

I am therefore of opinion that the supply in the case stated will be sufficient.

You also enquire whether in my opinion, the size of the locks in the above case, could be increased from 90 by 15 in the chamber, to 110 by 17, (the lift and number of locks full remaining the same) and the canal increased to 6 feet deep and 34 feet bottom, by procuring the drainage of 150 square miles in addition to the 80 square miles?

The additional water required for lockage in this case would be 399,360,000 cubic feet per annum. The increased size, might require an additional quantity of 60,000,000 cubic feet per year for leakage and waste, making the whole additional quantity required 459,360,000 cubic feet per year. If additional reservoirs were constructed (so as to catch the water that falls in the 150 miles,) of one third of the capacity of the main reservoir, I am of opinion that the supply for the large canal, with large locks would be sufficient.

As I have not your report describing the country in which your summit level is to be, and am unacquainted with that part of Pennsylvania, I am unable to give any opinion relative to any particular reservoir, or district of country. But if the above description applies in your case, as I presume it does, I feel confident that you will have an abundant supply of water,

Respectfully yours,

ASHBEL WELCH,
Civil Engineer.

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46. PHILADELPHIA, 10th month 25, 1838.

Respected friend,

B. AYCRIGG, *Engineer*,
Farrandsville, Lycoming co. Pa.

Thy letter of the 5th inst. was duly received, and would have been replied to ere this, had I been at home.

The pith of thy enquiry is, whether its my opinion, the state would be justified in making a canal, depending for a supply of water on the premises thee has given in said letter.

I reply I do not hesitate to say, it is my opinion, that they would be justified. Summing up thy data, it is, viz:

Reservoir 3 square mile, 20 feet deep,	1,651,200,000 cubic ft.
Summit level 14 miles, 6 feet deep. Area 84 acres. The reservoir is supplied by a drainage of 80 square miles, 9 in. depth of water, (in place 34 inches, the minimum fall of rain per year,	1,733,760,000 cubic ft.
A lock 110 by 17 ft. and 8 ft. lift, 14,960 cubic feet, allow to fill every 5 minutes in 24 hours, (or one day and night) for 274 days a year, is	1,112,699,520 cubic ft.

I presume above relations would be sustained, and for the following reasons, and cover all leaks, evaporation, &c.

1. The reservoir is at the summit, which can have its first level raised two feet, so as to aid the main Reservoir, equal to what it would leak, evaporate, &c. &c.

2. Half of the boating season, the current, rains, would keep the reservoir full ; so that the reservoir would not sink, only in the 4½ months remaining, and thus making the reservoir sufficient for three times the draft of water, required to fill the locks, during the 4½ months.

3. For all the leaks and evaporation below the few upper locks; reservoirs could be had, from the small streams running into the line.

4. If the supply be still doubtful, (though I have no doubt on the subject.) and the business gets extremely large, 150 miles drainage from Little Toby, and the natural flow from Clarion river, which thee states can be brought into the canal at the summit, must satisfy any reasonable mind. The canal can if made, be abundantly supplied by water.

I like thy views of having the lock 17 by 110 feet, and canal 6 feet deep. The 34 feet bottom is rather small, it should be at least 40 feet bottom and banks slope at least 2 feet base to 1 rise. As New York is now about building her canal over again, at vast expense, to get locks of the size thee proposes, and a wide and deep canal. Our state would be throwing away their first canal, like the Yorkers, but, with their eyes open to the great advantage of a large canal, and folly of making a small one, by adding perhaps less than 15 a 20 per cent to the first cost. By making the large canal, you quadruple its capacity or capability of business, and what is more, reduce the cost of freight per ton a mile, to one half, and perhaps one third of a 30 a 40 ton canal, like the present state canal.

Again a large canal will carry boats of 100 a 150 tons burden, all decked in, capable of going through our large lakes, large rivers and sounds, so that we open our whole interior, to vessels carrying freight as cheap as on old ocean, or on the Mississippi, and we shall moreover secure the New York trade, to the Ohio river, by our Pennsylvania improvements.

But reverse the case, and make a small canal like the old ones. The Erie canal enlarged, will not only take the trade from New York city, but even from Philadelphia. Only think of it, the Erie canal enlarged, ½ cent a ton a mile, is an abundant price for freight, exclusive of toll, or say $2 a long ton, from Albany to Buffaloe, toll say $4 and all parties amply and fully paid. This would tap our canals with a vengeance.

But make our canal large, and a continuous canal, and we have nothing to fear in our State from New York. The Lehigh canal and locks is enlarged for 71 miles. Delaware canal is 60 miles, has but 23 locks. The North Branch to Northumberland, has wood locks, now rotten and require renewing, these enlarged and the locks up West Branch to Farrandsville lengthened, and we have a navigation rivalling the Great Erie canal, in its enlarged state.

When thee gets down the canal where the water is abundant, I hope thee will not forget the true principle of pursuing a navigation, that is, to have the lifts as high as the ground and water is adapted, whether it be 5 feet or 40 feet lifts.

I am thy friend,
JOSIAH WHITE.

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47. WILLIAMSPORT* Feb. 25th 1839.

DEAR SIR:—I have always thought from the favorable situation of the ground, both as to materials, and levels, the large quantity of drainage which can be secured at a small expense, that a sufficiency of water could be had at all seasons of the year, but if to this be added the water of little Toby, about or below Brockways saw mill, the matter is placed beyond all doubt in my mind. I am now writing the honest impressions upon my own mind, as if the whole responsibility was resting upon me, and am

Very respectfully,
Yours &c.
†WM. WILSON.

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*Received since the communication was written. Inserted when in the hands of the printers, B. A.

† This gentleman made the examination, upon which the former report or that of 1827 was founded. He at that time was inexperienced and expressed no opinion. From subsequent information he now holds an honorable rank in the profession; is fully competent to decide the question and quite likely might have taken the same position that I have, if he had made a second examination when better acquainted with the subject. B. A.

48 New York, Nov. 15, 1838.

Dear Sir:—Your esteemed favour of the 5th ult., has laid by here waiting my return home from Virginia, where I have been unexpectedly detained, or it would have been sent to me there and answered at once.

The subject of your letter (i. e.) a supply of water for your canal from the West Branch of Susquehanna to the Allegheny, is one of great importance to the state and to the United States. I have looked over your statements with care, and if the country through which your canal runs, is as you describe it, rather a water tight soil, and not liable to great filtration, you are perfectly safe. If, however, you have porous soil, you ought to guard against loss of water by puddling well, so as to secure you against unreasonable loss. The estimate of 50 cubic feet per mile per minute, is only half what Judge Bates made on the Erie canal—but this is easily accounted for in the very porous soil where he made his measurement, and no pains taken to preserve water—canal new, and I presume same canal now would not take 30 cubic feet per mile per minute.

I see you have by your statement the means of resorting to greater reservoirs hereafter, if you think proper. I should be very much inclined to make larger lifts than 5 feet and run the risk of low water, or even of pumping up water, for a while, in a country where coal abounds, I should go to 8 feet, and when I had descended so as to secure plenty of water, I would increase to 10 feet. I think the saving in lock tenders and in renewal of gates, will justify taking the larger lifts, and relying on reservoirs or on lifting water by steam in case of need.

Have you ever thought about and entered into calculations to save water by side ponds, and could not these be built of wood and covered over, so as to prevent decay, or at least, to add to the common duration of wood, and probably, by the time your wood failed, you would test the whole plan, and perhaps find you could do without them if your canal was well made, secure from leaks.

I had my fears of the efficiency of reservoirs in our climate, because of the evaporation and absorption, but the test in Ohio where they have a shallow one (which is the worst of all) has rather tended to correct my mind on that point. Yours will be deep, and of course the evaporation will be much less in proportion to surface—and as you have other resource which can be commanded if required, you will be safe.

I should not agree with you in the size of your locks 110 by 17. I would never go beyond 100 by 15. if I had 6 feet water or 5 feet water. I believe the most profitable and useful boat for canal, situated as yours with great lockage, will be from 60 to 80 tons—never more.

You speak of the quantity of water falling annually at Lebanon. There is no doubt you have more water fall yearly at the place you are making your canal than falls at Lebanon.

Wishing you every success in your enterprise, I am dear sir, very truly your friend. BENJ. WRIGHT.

B. Aycrigg, Esq.

49. In addition to the remarks in the letter of Mr. Hage, I will quote the printed letter of E. H. Gill, Esq. civil engineer, to B. W. Bakewell, Esq. one of the directors of the Sandy and Beaver canal, December 1835, on the subject of the Licking summit of the Ohio canal.

"The reservoir receives the drainage of from thirty to forty square miles of country, and during all portions of the year it alone has to supply near thirty miles of the summit and its dependent level, with water, and during the dry season about forty-four miles of canal. At the period of my visit to the reservoir, which was during the driest part of last season, there was a flow from it into the canal of 1,329 cubic feet per minute, which at this time was the only supply received by the summit and its dependent levels. The average number of boats then passing was eight per day, to carry which across the summit required at least an expense of 12 locks full of water per day, equal to 112 cubic feet per minute. If to this sum is added 100 cubic feet per minute for leakage at the locks (which were in a very bad condition,) there will be left for evaporation and leakage on the 44 miles supplied from the reservoir 1,117 cubic feet per minute or 25 cubic feet per mile."

We will now proceed to examine the difficulties:

50. Various questions having been frequently put to the writer, and perhaps other objections and doubts felt by those who may be governed by them without speaking to those who might meet and answer them, the remaining part of the investigation is thrown into the colloquial form that the difficulties may be more distinctly stated and the arguments in answer rendered more perspicuous.

51. Do not the streams upon which you depend for the supply of the summit run almost dry in summer time?

Yes; with the exception of Little Toby, whose waters (coming from Boon's mountain, where the rocks that are geologically higher have been forced up by the lower strata, and thus admitting the rain to penetrate) are more constant than the other sources of supply, furnishing of itself, with the exception of a short time in the latter end of summer and beginning of fall, enough water for the canal from its natural flow alone, and if I can depend on memory, throwing out in the middle of the summer that we were there, about the same amount as that required from the Kiskiminitas to Pittsburg, or 3,000 feet per minute. Sandy Lick, upon which it is proposed to construct the reservoir, runs almost dry in summer, and since it is not obvious at first sight, I wish to press this subject forward for particular attention, for it shows, as mentioned in the report of 1837, that we have a country most suitable for reservoirs. This fact alone is a proof, that we can obtain a greater supply from a given surface than in other regions where the water is held back and exposed over a greater extent, in place of being immediately passed into the reservoir, where the evaporation will be but trifling, owing to its great depth and small surface.

52. Would the mere construction of a dam furnish a supply of water?

Yes, unquestionably with the addition of the neighbouring stream thrown into it, and almost beyond a doubt without its aid. Had nature in place of making an open valley, left an obstruction at the gorge and formed a lake with 14 miles of superficial area, with a depth of ten feet, and that could be drawn down five feet by a deep cut, no one would have doubted the supply, although it would not yield as much as the proposed reservoir, since the contents being the same, the evaporation would be more than four fold. This would have an imposing effect and be tangible, but there is an airy nothingness about an instrumental examination that will with difficulty produce the conviction, that where nature has furnished us with the raw material, art may effect an arrangement that will be of more practical utility than similar works of nature in their rough state.

53. The question has frequently been asked, do you not depend solely upon rain?

Yes; and upon rain alone depends every canal, river, or lake, except in Holland, or other places below the level of the ocean.

54. Would there be water enough to fill the reservoir?

To give my opinion, I believe that from the peculiar character of the country it will very nearly, if not quite, fill twice during the year. The calculations were made upon the supposition that it would fill but once, and found sufficient to supply the canal, but as a matter of caution, I have reported that it is possible, Little Toby may be required.

55. Does not the water run a great distance before it reaches the reservoir, as I observe it supposed in one of the letters?

No; this matter was not referred to in the circular, but the reservoir cuts off the head of the valley, the small streams radiate to it, and the most distant point from which the water would flow into the reservoir, not over 5 or 6 miles. As the rain passes off very rapidly from the steep water tight ridges, of which this region is mainly composed, very little is left for evaporation.

56 Would it not be absorbed or leak out?

An allowance is made in the calculations for a much greater loss from this source than will ever be experienced. That which passes between the horizontal strata cannot get out except near the dam, since this valley is lower than any other in the neighbourhood. The nearest is 6 miles distant and 35 feet above the reservoir. It cannot to any great extent, sink downwards through the horizontal strata, that are almost water tight, and the small amonnt that would filter through near the dam could be taken up by a small feeder dam below, so that the quantity lost would be extremely small. The loss by evaporation might be safely taken at 9 or 12 inches difference between the rain and evaporation on the surface of the reservoir. From observations of several years in three different places in England, the evaporation in that country would average 26½ inches, while their rain is taken at 31 inches, showing a gain, while our calculations would show a loss, and allow a total evaporation double that of England, or

52 inches, and in the estimate of the supply this loss is taken at a still greater amount, so that from this source we are certainly safe.

57. Would there not be more than 14 miles to be supplied from the summit?

In the actual construction of the work I should not reduce the maximum distance to 14 miles in dry weather, but leave it at 20 miles. With this arrangement we would have but one mile of canal, exclusive of the reservoir to be suppled from the summit until the dry season comes on, and then supply 20 miles, including the reservoir, or 13 miles without it, because I do not believe that we should find any difficulty in feeding 7 miles west and 6 miles east of the reservoir. Should the leakage from the reservoir be material, as taken in the calculation, a small feeder dam could subsequently, if required, be put in the creek to throw this into the canal, when we would have at the driest time not over 14 miles, and probably (from streams upon which I am not willing to depend) not over 13 miles, while for half the season we should have but $8\frac{1}{2}$, including the reservoir in both cases. As the question was the practicability and not the proper arrangement of the work, I stated what could be done, if necessary.

58. Is there not a better route than the one proposed?

No, that question is settled conclusively. Taking into consideration the position of the dividing ridge, it is remarkable that so many favorable circumstances are collected at this point. It is in the first place the lowest pass in the state—in the second place, the ridge rises steep, so that we can, with a tunnel, strike the valley low enough to enable us to construct the reservoir on a higher level, and thus feed from it both ways, while at no other point that came under my observation could the same thing be done (even without considering the necessity of drainage sufficient to fill it,) for the valleys of the other streams at the height at which a tunnel might be reasonably constructed, are generally narrow and descend so rapidly that a dam of the size proposed for the present would hardly hold a supply for 1 month's active trade—in the 3d place the reservoir being lower than Little Toby gives us the command of that stream if we require it—in the fourth place the valley has not only a very gentle declivity, but is also broad, and thus furnishes us with a large area—and in the fifth point of comparison in which it has the superiority, it is at the head of a stream that from its size and extent of flats furnishes a favorable route for the canal.—There is but one point in which it is inferior to its rivals and I consider the objection valid; it passes through the least inhabited district, but since it unfortunately happens that the greatest number who are interested in the local arrangement of the work cannot receive the benefit, it does not follow that a route combining all the facilities that nature has given to this region, should be deserted for some other which if not positively impracticable can at least offer nothing in comparison.

59. The letters that you have presented do not all agree; whence arises the difference?

From results obtained in different kinds of soils and under different circumstances and from different views of the same subject, some have calculated in one way, some in another. Some have gone into detail and separated the items, while others, together with myself have not thought that the present case required any nicety of calculation and have roughly made large allowances to cover every thing and satisfy the most extravagant demands. I do not think it necessary to object to any position taken in these letters since they all arrive at the same conclusion as far as practicability is concerned. I will merely repeat the observation made in my late report. The amount of water actually used to keep the canal full and supply the light trade during the driest time last summer, between the Kiskiminitas and Pittsburg or 29 miles. I ascertained by gauging, to be 102 cubic feet per mile per minute.—The first lock below the aqueduct is ten feet lift and this amount of 102 cubic feet per mile per minute was the total amount of leakage, evaporation and lockage. The trade however, was nearly suspended. I do not know its amount, but it can be ascertained from the date, 7th September,

60. There are several reports adverse on the route by way of the West Branch. How can you reconcile the different statements? And how can we decide between them?

By observing that there is no difficulty on the West Branch itself, but merely at the head of its tributaries, which are as distinct from each other as the West Branch and the Juniata, but still the name of West Branch is applied to all, because, that river is common to all. Again, before the last examination was made, there was no doubling of reports or examinations of the same pass. And finally, that although upon this route there was a former report, still, a different result might reasonably be expected from the examination of one who himself informed me previous to my beginning the work, that he had never seen a level before he commenced on the Elk and West creek summit the preceding year, and of another who had long been under the instruction of the best professors in acquiring the preliminary information, had at the time he commenced the examination, been already for nine years actively engaged in the duties of his profession, having commenced in 1827 on the Lehigh canal, and from the exploration to its completion, had an opportunity of studying the plans of C. White, carried out by S. Welch. Had for several years subsequently, the benefit of the experience of C. White, while acting first as his assistant and then up to the time of his death in consultaion on the new works of the Union canal, and moreover, in addition to every advantage and opportunity of becoming both theoretically and practically acquainted with his profession, had for years, both during its construction and use, been familiarly acquainted with the works on the Union canal of precisely the description required in the present case, and had consequently chosen this exploration, believing that from his knowledge of this subject, he might succeed where others who had not enjoyed the same opportunities might fail.—Should any thing more have been expected from the former examination? made by one who was almost totally inexperienced, (for one year levelling in the woods will not make an engineer, although some may maintain the contrary, and believe that a "good millwright must necessarily be a good engineer," or as Horace, ironically remarks of the wise man of the stoics, must be "a good shoemaker, although he never learned the trade.") Thrown entirely on his own resources, in a wilderness country, and with an intricate question before him?—What he did was done with accuracy, as far as his experience went, and he is no more to blame for any omissions than a master workman for not having understood his business, when he was but an apprentice. It is not intended to draw a personal comparison. One man may learn more in one year than another in twenty, but supposing them to be naturally equal, the difference in experience should certainly be taken into account.

Let none suppose that any disrespect is intended by those remarks, or that the writer is vainly thrusting himself forward. The former, now holds an honorable rank in the profession, and claims nothing for his early work, except accuracy in the mechanical part of levelling, and had too much good sense to express a decided opinion upon a subject with which he himself says that he was not acquainted.

61 That he did not pretend to judge of its practicability, is evident from the following remark in his report, extracted from Journal H. R. page 94, 1827--28.

"I have endeavoured to communicate all the facts connected with each of the routes upon which I have been employed, and the schemes upon which the examinations have been founded, as no survey of a summit can be made unless the person employed has some plan. As to practicability it is not for me to determine."

As to the latter; he is well aware that he subjects himself to the charge of egotism, but where the individual is frequently alluded to, he considers it proper to speak of himself as an individual, and would be chargeable with weakness, should he from a false delicacy hold back, when this furnishes an important consideration, and argument in favour of the position that he has taken. That this is now a very plain question, is no proof that it was not a difficult investigation. It is now a very simple matter to ascertain the precise position of a ships at sea, but the reasoning that led to it is by no means simple, and the world had grown old before the discovery was made, and it required even the inventive genius of Columbus to teach us how to make an egg stand on end. A man of ordinary capacity, may apply a system suggested by his own experience or the experience of others and gain a result that would elude the grasp of the strongest mind when called to act upon a subject that is new to it.

62. It is true that the report was made by an experienced engineer, but according to the concurrent testimony of those residing in the district, substantiated by the internal evidence in the report itself, it appears to have been a mere matter of form, founded upon the data furnished by the notes of the former individual, and after a cursory view of a few days.

That he made no examination that could lead to useful results is evident from his report which states that he left Curwensville, Oct. 29, went on this route and found it impracticable, and thence went to the summit at the head of the West Branch, and appears to have paid more attention to it than to the former route, procured information on the subject of the expense of iron pipes, and reported in Philadelphia on Dec. 14. We might therefore infer that he did not examine this county, even if we had no positive testimony on the subject.

As his review of Mr. Wilson's proposed source of supply for this summit is finished in very few words, and as it is in fact the only report that we have on this subject, from a practical engineer (since judge Geddes, had nothing to do with it, although the contrary opinion is very common) I will here quote the whole report verbatim, as far as relates to the proposed line, from the journal of the House of Representatives, 1827-28, page 96, viz:

"In pursuance of these instructions I proceeded to Curwensville on the Susquehanna river, where I met Messrs. Wilson and Mitchel, and on the morning of the 29th October, after having made the necessary arrangements we proceeded to the summit, lying betwixt Sandy Lick and Sinnemahoning. This summit is five miles and sixty chains long, and the amount of water which can be brought upon it is 424 cubic feet per minute, which will be supplied by the following streams, viz: Summit creek, Fall creek, South East or Luthers branch, Rattlesnake run, Fourteen Mile run, Whetstone run, and Beaver run. Below this summit on the east side, passing down the Sinnemahoning four miles, an additional supply will be obtained equal to 59 cubic feet per minute. On the other side following the Sandy Lick four miles and sixty-three chains, 50 cubic feet per minute will be obtained. Thus the whole quantity of water, which will be supplied by streams is 533 cubic feet per minute, and the whole length of the canal to which this quantity is applicable, is fourteen miles and forty-three chains.

We therefore perceive that allowing the requisite quantity here for evaporation and filtration to be equal to that upon other canals, viz: 50 cubic feet per minute for each mile, that these two items would amount to 722 cubic feet per minute for each mile, which exceeds that of the above supply by 189 cubic feet per minute. To compensate for this deficiency and to obtain a supply for the locks, it is proposed by Mr. Wilson to construct an extensive reservoir in the valley of Sandy Lick. It is to cover 250 acres and its surface to have an elevation above the surface of the canal of four feet, so that the whole of its contents to that depth, in case of necessity may be used. This reservoir, allowing it to average four feet deep, would contain forty three millions five hundred and sixty thousand cubic feet of water, equal to 252 cubic feet per minute, for a period of four months. From this, if we take the above mentioned deficiency of 189 cubic feet there remains only 63 cubic feet for the supply of the locks, a quantity so palpably inadequate that it is unnecessary to say more on the subject."

PHILADELPHIA, Dec. 14, 1827.

I must here again bring in myself but it cannot with propriety be avoided.

I did not review the work of my assistant, although he was an engineer of several years of experience. I depended on no one for my information, but gained it for myself by my own exploration, and myself directed such instrumental examinations as I wanted. I drew my conclusions from my own personal knowledge of the country and to ascertain what required the instruments frequently travelled four or five and even twenty times as far as the main party. Had I trusted to an assistant to procure the notes upon his own plan, I should have been able to tell whether this would effect the object desired. But I did not go out for the purpose of determining whether a first, a second, or a third plan might not answer, but whether there was not some plan that would answer. This, in a country that is mostly a trackless wilderness is not to be done in a few days. It required months of constant labor and minute investigation before I had satisfied myself that I could comprehend the whole district and all its circumstances and form a correct opinion of its resources.

There is no intention to blame any one, but merely to state facts and show that the two reports are founded on totally different bases. I will not undertake to say why he did not examine the country, but merely that he did not, and to repeat the remark, that before the year 1836 there never was an examination of this summit, by one who even professed to understand the subject.

But even supposing the reverse; it does not follow that because frequent attempts at making use of the steam engine for propelling boats had failed, no one should succed. If you show an intelligent mechanic a defective plan of machinery he tells you it will not answer, you show him a perfect plan and although he may never before have seen the contrivance, he is surprised to find it so simple, and answers at once from his general knowledge of mechanics, this will work admirably. There is no need of his seeing the iron, brass or steel of which the work is composed for he can reason quite as well from the plan. The same would be true of a canal, and an engineer of judgment could pronounce as certainly upon the practicability of feeding a canal upon a plan proposed to him when you give him a full statement of the facts and circumstances as if he had seen the ground on which the work is to be constructed. The former plan proposed for the supply would not give enough, the latter more water than we want.

63. You speak of a formidable tunnel to Little Toby; is this necessary?

I think it is not, nor was it introduced into the report until it had been given to the commissioners, and then upon the repeated advice: "if you know it will answer, put it in by all means." I am pleased it was inserted, although as I foresaw, it has been a grand objection.—There is very little probability that it will be found necessary, still it is the source of unhesitating confidence in the success of the work. Even if we could not get this water, the canal ought to be constructed, depending upon the reservoir alone, that will in all probability be sufficient, but it certainly should not be an objection, that we can get more if we want it.

63. Are you not too sanguine, guided by your feelings, not your judgment and is it not possible that this is a visionary project?

I am well aware that I subject myself to this charge. We risk as much with some persons by being in advance of public opinion as behind it.

A man who speaks with warmth and decision receives no confidence. They would sooner trust one who dare not from undoubted facts draw an opinion of his own, but keeping on the safe side watches the course of the popular current, and is always orthodox, although he may affirm one year what he will deny the next, or perhaps never express a decided opinion but allow others to think for him and govern himself accordingly. A proper discrimination is not always made between firmness and obstinacy. Some have ridiculed the proposed connexion, but I hope that those who are open to conviction will be satisfied after they have finished this communication, that what they supposed rashness, in supporting positions that are untenable, is in reality, firmness in maintaining conclusions drawn from undoubted facts and calculations that cannot be refuted.

If men may retain their standing as philosophers when holding doctrines, that to others appear ridiculous; if Anaxarchus will not get out of the road when a carriage is approaching, nor avoid a precipice, believing them visions of the imagination; if Burkeley denies the existence of matter, and Des Cartes requires an argument to prove his own existence, it is no cause of surprise that men should doubt almost anything. It is easier to doubt than to take the trouble to examine and form a positive opinion, and in a case where millions are concerned less expensive to doubt than to be deceived. It was not anticipated that the public would be readily brought to trust in the practicability of the proposed connexion. In my own mind the year 1852 was fixed as the date for boats to pass the summit, allowing ten years to ripen the belief that it could be done, and five years to do it.

Although it may now be put down, it will work its way though in the end. The world has seen greater changes than this. In former days the earth was the centre of the universe, and Tycho Brache persecuted for maintaining the doctrines of Copernicus, that are now the foundation of all our astronomical calculations. China as represented at home at the present day occupies three fourths of the earth. France, England, Germany, Russia, &c. are small islands on the borders, and America. a speck in the corner of the map. At the time the Aristolelian philosophy was mixed up with the doctrines of the church, "nature abhorred a vacuum," and Torricelli found himself in difficulty for maintaining the truth of a philosophical fact. The man who first took Anthracite to Philadelphia, was abused and threatened prosecution if he did not take away the stones that he had imposed on them under the name of coal. During the construction of the Union canal, the neighbours were much amused and exercised their wit at the expense of the persons engaged on the locks and bridges that were to lock up the wind and carry them over a dry ditch, while some thought them fools. and others thought them impious to attempt by means of machinery, to force water up hill through iron pipes, contrary to the laws of nature, although it was quite natural for them to use their arms upon a good legitimate wooden pump, to draw water from the bottom of their wells as their fathers had done before them. Brindley and Bridgewater were mad when they built their "castle in the air," and Clinton, foolish in his views of internal improvement, but each has received a lasting renown from the success of his long sighted views.

I do not mean to compare myself with these men, for the proposed improvement has become too common to be any longer considered an experiment, nor is it intended to say, that those who do not agree with me as to the connexion, are not better acquainted with engineering than the Chinese are with geography. These instances of errors that were in some cases almost universal, have been offered with the sole object of bringing those who have set their minds against the work, to doubt whether they may not possibly be in error themselves, and lead to a fair examination of the subject.

An impartial verdict is all I ask. If the present examination be not sufficient, let others be made by one two or more engineers, either in consultation or separately. Let them ascertain the facts, and the difference will be found in the fractions not the general result.

As to my being too sanguine, should I not with greater justice be considered too cautious? I believe that we will from the reservoir alone have more water than we can use, I still will not risk a positive assertion, that we can do without the feeder drift, although well aware that it may keep back the work that I feel so anxious to see commenced. When with all the water that we can command, I feel confident that we will have three times and in all probability four or five times as much as we want (not to make the canal profitable, but to pass the boats as fast as the locks can be worked,) should I not be chargeable with weakness, if I had not the moral courage to oppose what I believe an unfounded prejudice, and positively assert that we will have enough?

65 Have you not a pecuniary interest in the construction of this work? And will not the loss fall upon the commonwealth, not upon yourself in case of failure? Have you not every thing to gain and nothing to lose.

The case is precisely the reverse. This work may be made when I am elsewhere. The time is uncertain. It is doubtful whether I should have any part in the construction, and consequently in point of salary, I should receive nothing, while as a citizen whose property 200 miles distant, is of the kind most exposed to taxation, I should suffer as heavily as my neighbours from a wasteful expenditure of the public money, and as an engineer, having confidently asserted its practicability, I should destroy my business, for I could not after so signal a failure, ask a company or the commonwealth to put any credit in my statements. I have thus every thing to lose and nothing to gain, except in point of honour for having found what others did not, and solved the problem of a continuous water communication to the west through the state of Pennsylvania, and that too not over a mountain as many suppose, for the reservoir will be about 80 miles beyond the main ridge of the Allegheny, nature having already formed a pass for us through this obstacle, in other places so formidable. In place of crossing a mountain, the proposed line passes over a summit more than 1200 feet lower than the natural summit of the Chesapeake and Ohio canal, and but 244 feet higher than the basin at Johnstown. I have been long enough engaged in engineering, to appreciate fully the heavy responsibility I have assumed by the course I have taken, but I have also been engaged long enough to know what confidence to place in my own examinations and opinions. This subject has now for three years engrossed all my thoughts of business. There has been time enough for reflection, but as I thought at first I think still, and it would be the height of my ambition to have an opportunity to test the mattter practically. I speak confidently, because I have no doubt on the subject; and with energy, perhaps enthusiasm, because I do not fear to advance boldly, after having cautiously examined the whole matter, and found that it would bear the test of the severest scrutiny; because I wish to see the work constructed as a matter of national importance; and from a more selfish feeling, because I wish to see the success of my own plans.

66. Could not this question be practically tested by making a part that would be useful in case of extension, but not a heavy loss in case of failure?

Yes, very easily, construct the dam without any other part of the work, after having, as proposed in the report, continued the former examination to the details and settled the proper height. This would cost the commonwealth about $65,000 00, or perhaps more, according to the height and plan, and might be commenced immediately, for the examination would be finished before the level of the top would be required, and the position of the dam is distinctly pointed out by nature.

This being done, no doubt would remain, either that we would, or that we would not have a supply. If by any possibility we should require the waters of Little Toby, although, I do not think that the probability amounts to one per cent; this, with all its appendages would not cost over $200,000, since, as may be easily gathered from the report, it was intentionally estimated as far as the tunnel is concerned at nearly double what I supposed it would cost. In that country where the material is well known the expense of tunnelling can be calculated as closely as open work, but the amount was increased from a knowledge that many have a superstitious dread of subterranean works, although in a mining country an objection would be ridiculed since you can not get miners to work exposed to the weather. In a single mine in England (that the writer visited last year,) with a single shaft, there are 40 miles of drift or tunnel larger than the one proposed, crossing each other like the streets of a city, and at 1500 feet below the level of the ocean, while the depth of our tunnel would average about 50 feet below the surface of the ground. In this state, in Schuylkill county alone there are hundreds of miles of this kind of work, and they are constantly extending.

If the difficulty be the expense, although the sum be large, it is a trifle in comparison with its importance.

67. If it be thought that I have no risk in pressing this work, I will make it evidently so. If other professions have contingent fees I see no reason why the same may not in a case like the present be extended to Engineers. I therefore make this deliberate offer. I will guaranty a supply as far as salary will go. Appropriate the funds as fast as called for in the execution of the work, allow me to pursue my own plans and I will depend upon my own resources until the work is completed, without drawing a cent of pay from the treasury, and then either receive nothing or be paid double salary for the time so occupied, according as it prove a failure or a triumph. I would for the first year not go beyond the dam but reserve the privilege of extending to Little Toby, if by any possibility it should be found necessary.

I would then stand or fall as an engineer by the result of my predictions. I have no fear of losing my work and reputation at the same time, but I would be highly gratified in receiving the honour of effecting a navigation that would rival in importance the great canal of New York, and be one of the noblest works in the country.

This is no idle boast. I am willing and would gladly make such an arrangement immediately, or at any time when not otherwise engaged or having a greater objection to a life in the woods than I have at present.

Having then effected the object of my ambition, I would bid adieu to the turmoil, jealousy, and uncertainty of state engineering and leave others to make the necessary works for the reception and use of the water sent down to them from the summit.

This article having increased in length, so far beyond what was anticipated, will probably not be examined, except by those who feel an interest, either professionally or personally, in the matter, and who would not object to a still greater extent, provided they might thereby gain more light on the subject.

68. I will, therefore, continue and show the results that I expect when the work comes to be executed; first, having stated that this is not an estimate but an opinion. The former I consider a promise or an assertion, that a certain thing can be done, and the engineer held responsible for its accuracy, and he must, therefore, take such a ground as to leave himself perfectly safe, when the result is ascertained. Upon this principle I have asserted, and have been fully sustained by the highest authority in the country, that an entire water communication, with an abundant supply of water, is practicable. The following calculations, I give as a matter of opinion. I believe that the result will prove their accuracy, but I do not hold myself responsible for their fulfillment, especially when there is no need of my assuming this gratuitously. I have not enquired as minutely into this matter, as I should have done, had it been necessary, and the supply doubtful, but I shall go into detail, and think that my premises and deductions will not be easily set aside.

At the conclusion of one of the paragraphs in my report on the summit, is the following remark: "leaves a surplus of 493.8-4,000 " cubic feet or nearly one fourth of the whole, after allowing the boats " to pass the locks more rapidly, and wastage to be greater than will " be the case, unless the canal should be supplied with double " locks."

69. Let it be held in mind, that none of these calculations are made to ascertain whether we will have the water, to pass a trade sufficient to make the expense of the work a good investment, but whether there would ever be a deficiency, supposing a constant supply of boats night and day, one being ready to enter the lock as soon as the other leaves it.

70. Without looking to the immense income from such an amount of trade, no one can imagine that we will ever see boats passing every three minutes, supposing it even possible to work them through so fast, and without intermission from the beginning to the end of the navigation. From the time the ice melts until it forms again, 20 boats per hour, or 480 boats in one day! The exaggeration of the other calculations are not so great as this, nor yet so obvious.

71. To explain the reason why every thing was taken in excess, I knew that public opinion was decidedly set against the belief, that a water communication was practicable, and consequently, that I had to contend against popular prejudice; I found on the other hand, such extensive supplies, that I was able to make the most liberal allowances, and still have a surplus, and therefore, to fortify the position that I had taken, stated the question in such form, as not to leave a hook to hang a doubt upon, should any one enter into the examination, and observe the monstrous amounts that I had calculated, as either lost or used. I was surprised to find so many give up their previous opinion, and believe that we would have an abundant supply. Now that the question has been before the public for 2 years, and prejudice against the route so far silenced by conviction, I will take up the facts mentioned in the report, (for these are all stated correctly, however much the deductions from them were exaggerated unfavourably,) and show the probable result.

72. I must correct one misstatement made in the circular. The 14 miles to be supplied from the summit, are not composed of 10 miles reservoir, one mile of tunnel and 3 miles of canal. I found 14 miles mentioned in the report, and I spoke from memory, as to the length of the reservoir, or the summit level, from the dam to the tunnel, and confounded it with the 10 miles of summit, when the reservoir is drawn down. This reservoir summit, I find from a reference to the the maps, deposited in the canal commissioners office, to be about 7½ miles, so that to state the case exactly, we have 5½ miles reservoir, 2 miles deep cut, on the summit level, 1 mile west of the dam to the feeder dam, 1 mile tunnel, and 4½ miles east of the tunnel, to the mountain run, of which last distance, 1½ miles are on the level of the tunnel, or summit level, when the reservoir is drawn down, making that summit in low water 10 miles. This in place of

being an objection, is the reverse, and makes the case more favorable since it leaves us but one mile exclusive, of the reservoir and deep cut on the summit level, or a total of 8½ miles, including the reservoir, to be supplied from the summit except in dry times, so that the allowance of 14 miles was too liberal when taken as an average,

73. To state probabilities and results of the supplies that I anticicipate for a canal of larger dimensions than that upon which the estimate was formed; or for boats of 100 tons, requiring locks of seventeen feet wide, and 110 feet long, and water six feet deep, and with locks eight feet lift instead of five (as proposed by Judge Wright and in which respect I agree with his views, but from motives of prudence, did not think it well, at that time, to propose eight feet when the public might hesitate with the smaller lift, and only dared to hint at an enlargement of the canal,) I should arrive at the following results:

74. I have very little doubt, but that two-thirds, or sixty-six per cent. of all the water runs off by the streams, for we can hardly immagine a district better calculated to discharge the water rapidly. I will, however, for the sake of certainty, take the amount at 0.523, as stated in the letter of Simeon Guilford. As mentioned in my report, and again by Judge Wright, there is no doubt but that more rain falls at the summit than at Lebanon. We will not, however, increase the quantity, but take the smallest amount at Lebanon, or 34.49 inches. We would, therefore, be safe in taking the drainage at 18.04, say 18.00 inches. This, from eighty square miles, will give us the reservoir twice full, or fill the reservoir if twice as large;* or to calculate closer. 18 inches would give us 14.907,200 cubic fathoms per annum, on seventy-seven square miles drained, and three square miles falling immediately into the reservoir, at 34½ inches = 1,113 200 cubic fathoms, total = 16,020,400.

75. Average evaporation of three places in England—at Kendal three years, 25.157—at Tottenham, eight and a half years, 30.467—at London, three years, 23.974, general average 26.53 inches. Our reservoir is deep and, keeping cool, the evaporation would be less than from a gauge hung up in the air. We have not allowed an excess of rain above other places, and we will here pursue the same course, and keeping on the safe side, allow our evaporation to be double that of England, or 53 inches per annum. It is too much, but we can spare it; Mr. Miller and Mr. Faries take it at 35 inches; Mr. Hage quotes Smeaton, who states that four months drought (in summer,) will not lower a reservoir more than ten inches. This would give us thirty inches per annum, and also must include absorption. I think than no one can, therefore, object to this amount being too favorable.

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*Note.—There is no need of making the reservoir any larger, for the purpose of supply, since the water does not all fall at one season and require to be kept for another. but coming irregularly requires the reservoir t act as a fly wheel and regulate the discharge.

76. Absorption is another item of loss. This, I believe, will from the character of the ground or rather rocks, be extremely small except near the dam, but I will take the largest estimate given. Mr. Miller allows six feet over the area. This with the assumed evaporation gives us not 2 feet 6 inches, as stated by Smeaton, taking not the average of the year, but a summer drought, but 10 feet 5 inches loss by absorption and evaporation. This on a surface of 3 square miles=4,033,333 cubic fathoms.

77. We have also the loss on 5½ miles of ordinary canal. Mr. Douglas estimates this at 100 cubic feet per mile per minute. Mr. Guilford 50, Mr. Mifflin 50, Mr. Miller 100, Mr. W. M. Roberts 50, Mr. Welch 60, Judge Wright 50. My own observation on the Allegheny, showed 102 for this item, including lockage. These different estimates arise from examinations of different canals at different ages, and in different kinds of earth. But as the size of the canal that I propose is larger than the present, I will take the largest estimate, and say 100 cubic feet per mile per minute loss, or in 240 days on 5½ miles=880,000 cubic fathoms. To this add the leakage and evaporation from the reservoir, and we find the total loss from the part supplied from the summit=4.913,333 cubic fathoms.

78. The position once granted, that we can get as much water from drainage as Mr. Jervis found on the Chenango canal, and only $\frac{5}{6}$ of what they get at the Shaw water works in Scotland, and considerably less than I anticipate from the peculiar features of the country, I think that no one will undertake to controvert the other points since, I have taken the leakage from the canal, the evaporation from the reservoir, the absorption of the reservoir, at the largest amounts given in any of the communications, and even to the evaporation, added an extra amount. I regret that I have not at hand the report of Col. Trimble, who having a closer question, has examined the subject more minutely, that report and other matters that would now be valuable, were left behind, as I did not expect to enter so fully into this question.

79. We will now collect these items.

Evaporation of reservoir	52	inches	three square miles
Absorption of "	72	"	
Total depth	125		
Total loss on reservoir	4,033,333	cubic fathoms	
" loss on 5½ miles of canal	880 000	" "	
Total loss to be supplied from summit	4,913.333	" "	
Total amount received	16.020,400	" "	
Amount left for use	11,107,067	" "	

80. Two of the letters contain calculations of the amount required to fill a long piece of canal. As it was not mentioned in t circular, the writers were not aware that there will be a supply to f all except one mile without drawing from the reservoir. Five and half miles on the Eastern side will be supplied to the amount of

loss by streams that will be sufficient for a large part of the season, although they have been thrown out of the calculation, and the distance taken to one of the large branches that comes from Boons mountain. I therefore consider it almost unquestionable that we will have the full amount of 11,107,067 cubic fathoms for use.

81. A lock of the proposed size 17 by 110 and 8 feet lift, will require 69.26 cubic fathoms, or the total available supply from the drainage immediately into the summit=160,368 locks full, or supposing the boating season to continue 240 days, there would be sufficient for a lock full every 2$\frac{1}{7}$ minutes! or a discharge of 6942 cubic feet per minute for lockage alone. Taking the half of this at each end of the summit, and we would have 3471 cubic feet per minute for lockage, and 550 allowed in the calculations for loss on the canal 5$\frac{1}{2}$ miles, making 4021 cubic feet per minute.

82. This gives a surface velocity on a canal of the present size, of 8.29 inches per second or 0.47 miles per hour.

Can any one suppose that we will ever require to pass boats with this rapidity?

83. With this result staring us in the face, even allowing that we will not get one half the amount calculated, with the knowledge that the calculation is founded on but one third of our available resources. With the knowledge that the Licking summit of the Ohio canal is supplied 30 miles and at times 44 miles, when not a drop of water runs into the reservoir and that the reservoir contains less than half the amount of the proposed reservoir, and drainage not one half, and in a country vastly inferior for the collection of water, and a canal to be supplied from twice or three times the distance. When we know that the summit of the Union canal is kept up when almost every canal depending on the natural flow runs nearly dry, and that their 11 to 15 miles supplied from the summit depend entirely upon a reservoir that is but one-fifth of the one proposed and that of this amount they get ut about one sixth into the summit. Is that man to be called a vision-ry enthusiast who asserts that with all our means we can do what thers have effected with so small a proportion? Would he be wrong maintaining that the reservoir will not for years sink 10 feet before rains bring it up again?

84. If we could get no more water than that supplied by the reser-ir, I should have found it necessary to procure more precise data on which to found a close calculation, and I do not hesitate to say at I believe it would have resulted in the conviction, not only that e would from this source alone have enough water to make a canal of the present size a profitable work, but there would be a large excess with the canal of the size just calculated or for boats of 100 tons and to pass in succession, night and day the whole boating season as fast as they could be worked through the locks.

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* No notice has been taken of the two miles of deep cut, since it forms part of the reservoir extending up to the tunnel.

I have not however, collected all the facts within my reach, (and some that I have are not at hand at present, from the cause before stated,) since I did not consider it necessary, when I knew that at an expense about twice as great as the bridge at Duncan's island, or 30 per cent greater than the aqueduct at Pittsburg, we could by means of a tunnel that when done would be finished, and not like them, require constant expense in repairs and renewal, secure a supply from Little Toby alone (without taking into account the 20 miles of additional drainage on the eastern side of the ridge, nor yet the Clarion river,) nearly double the amount of that from the reservoir, while this alone can be shown both by calculation and experience, in other places to be more than sufficient.

85. I will not therefore, gratuitously assume the responsibility of asserting that the reservoir alone will be sufficient, because I know that we can get more and greater supplies at any time that we require them.

86. I will reiterate the remark, for it should be borne in mind, that the above calculation of supply, is not for the present sized canal, but for one intended for boats of 100 to 120 tons.

87. I doubt whether it would be good policy to increase the size of the Juniata canal, until they can discover some way, at present unknown, to make a thorough line. When this is done and a supply of water obtained, not only for the part over or under the mountains 36 miles across; but, also for the present canal from Hollidaysburgh to Huntingdon, and from Johnstown to Blairsville, the Juniata will have the advantage on the route to Pittsburg, and be equal to the West Branch on the route to Franklin, unless the difficulty of the navigation should be greater, for the actual distance from Middletown to Pittsburg, is 69 miles shorter, but to the mouth of Red Bank, on route to Franklin is 1 mile longer. In the mean time, setting aside the advantages of expedition and certainty, supposing boats on the West Branch route to be no larger than those on the Juniata, the expense would show a difference equal to 95 miles in favour of the West Branch on the route to Pittsburgh, and 165 miles on the route to Franklin.

88. But as this will be a thorough water communication, it should be larger the whole distance, from Philadelphia including the Union and Schuylkill canals. Take the statement contained in the letter of Josiah White, and calculate an equivalent for the distance, when the expense of freight is reduced, by the use of large boats, and toll reduced as trade increases; ascertain the neutral point between the the expense and risk of sending produce, &c. by way of the Mississippi, compare that with the present, and ascertain the amount of business this canal will make for itself. A trifling difference in expense, will decide the course of trade, and those who can offer a little greater advantage than others, will receive the whole profit of the transportation. Reflect that although the toll produce a revenue, still the facilities for our citizens to send off their produce and manufactures, by the great lines without being em barrassed by a trade, that chokes up the avenue, is of eq importance, that there are competitors on the north and s

of us. That the remaining portion of the route on the West Branch, is but 148 miles beyond that now under contract, and entirely through one of the richest mineral regions in the world, and that the utility of our bituminous coal, in smelting iron ore, can no longer be questioned; that by completing the connexion, we take away the the large rock that obstructs the passage, and prevents the use of a turnpike road, or in other words, bring the present long line, stretching towards this region, from its present dormant state, into life and activity, and virtually increase the territory of the Commonwealth, by converting the wilderness into a settled country, and it would appear that a doubt could hardly exist as to the "expediency," of the "West Branch Extension." It would also appear, that the same conslusions must necessarily be drawn from the preceding examination as to the "practicability," of supplying it with water.

Since the above was written and presented to the House, a letter has been received from William Wilson, Esq. of Williamsport, and inserted by the printer, in its alphabetical order, among the answers to the circular. (See Article No. 46.)

This letter is important, as it comes from the only individual besides myself (with the exception of our respective assistants) who has a personal knowledge of the ground.

When he made his report, he did not pretend to judge of the supply, as may be seen from the quotation (article No. 60.) Now the case is different. His experience in engineering gained since that time, brought to bear upon the facts ascertained by his own and the succeeding examination, enable him to speak with confidence, and as may be seen by a reference to his letter, he has no doubt as to an abundant supply. The only documentary evidence that now remains against the work, is contained in article No. 61, and this I consider as worth absolutely nothing, as to the supply upon the present plan. I have no acquantance with the author of that report, or I should have asked his opinion upon the present plan, and think that he would have arrived at the same conclusion as all the others. He would not thereby have contradicted his former opinion, for he was undoubtedly correct in his statement. From the accounts of his visit, derived from different sources, he did not travel over more than ten miles of the line at farthest, nor see half the streams mentioned in his report, and from which the supply was to be received. The data were furnished entirely from the notes of Mr. Wilson. It will be observed that he states nothing to the contrary, but merely applies the results of experience to the plan proposed at that time, and thence draws the correct inference that this will not answer. He does not say that he has examined the country, that nothing better can be done, and that it would be impossible to supply this summit, but merely, that this "quantity is so palpably inadequate, that it is unnecessary to say more on the subject." If I may be permitted to imagine the reason why the report comes to us in this form, I should say that he may have pre-judged the case and considering the matter self evident, did not think it worth while to waste time in hunting for what he did not believe could be found. Another reason may have been, his want of confidence in reservoirs, for at that time the subject was but little understood in this country, and if reservoirs will not answer, we should find a deficiency of water after the middle of summer. Finally, if at this time it requires some little nerve and resolution to brave popular prejudice, when we have both tunnels and reservoirs in abundance in the country, and their utility tested, how would he at that day have been ridiculed, had he came forward and made precisely the same report that I have done respecting this work? If at this time it is "visionary," at that time it would have been the wild fancy of a deranged imagination. If at the present day the engineer must calculate to injure himself in public estimation, and be obliged to look forward to some future time when he shall receive the credit of his work, at that day he would have blasted his reputation, and no one would have placed any confidence in his judgment. When making a report to a board of intelligent men, the difficulty is much less. The engineer can sit down quietly and convince them one by one, that it is their interest to carry a certain project into effect. But if even here he is to be met with that formidable word "visionary" in a mere calculation of dollars and cents, how much more cause has he to fear the judgment passed upon him by the public at large; intelligent and ignorant, those who "know a little, presume a great deal, and thus jump at the conclusion," and others who condemn it because they know nothing about it, among all the conflicting views of politics and personal interest?

But whatever may have been the cause, that report has no bearing on the present question. Nor have we to contend with the report of Judge Geddes. That was made entirely respecting the connexion of the Drift Wood branch with the Clarion river North of Boons mountain. He knew nothing of the proposed route South of Boons mountain, and between Bennets branch and Sandy lick, since the examination was not made until he had left the service of the commonwealth.

If, therefore, confidence can be placed in any project before it is actually carried into effect, the practicability of a supply cannot admit of a doubt, when sustained by one of the strongest collections of the unanimous testimony of the first men of the country, that has ever been brought to bear upon any of our proposed improvements. Its practicability being established, its expediency cannot admit of a question, since, without crossing a mountain, we can reach the west by a summit 500 feet lower than that of the Chesapeake and Ohio when cut down 861 feet by a tunnel more than four miles long; 927 feet lower than the Allegheny Portage summit, and but 244 feet higher than the basin at Johnstown. Reducing the expense at the lowest calculation, from Philadelphia to Pittsburg, if the size of the canal be not increased, equal to fifty-seven miles of canal, and to Franklin 127 miles; while, if the size be increased, the reduction will in the former case equal 129 miles, and in the latter 198 miles.

The matter having been fully examined in the former part of this communication, it is unnecessary to recapitulate, and I therefore take leave of the subject, in hopes that no question will remain except time and expense. As to a rough estimate, without further examination, I think that the entire work connecting the West Branch improvements, with the western division, on the route to Pittsburg, would not exceed six millions and a half, allowing the line to cost twenty per cent. more than has been estimated for the smaller size. To finish the whole and extend up to Franklin, would probably add something less than three millions, making the extreme nine millions and a half, for boats of a hundred tons. Should the canal be of the same dimensions as the present, the first cost would be materially less, but I should consider it a wasteful economy.

I speak without notes, but from my knowledge of the general features of the country, I think this would be a safe calculation.

89. ALLEGHENY FEEDER.

As this work forms part of the connexion, a few remarks in addition to those made in my late report will be in place in the present communication.

I consider it highly important that the law should be so altered as to admit the level to be raised to the height of the aqueduct, although the amount of work thereby abandoned will be greater than I supposed at the time the report was made. No exact estimate has been taken, but whatever the sacrifice, it should be done.

Again. I think the dimensions ordered by the late board of commissioners, entirely too small.

The canal will undoubtedly be continued to the Beaver line. It may not be done for several years, but when finished it will require a heavy draught of water for its supply from the Allegheny river, unless a resort be had to steam power to feed the level from Allegheny town to Beaver. In dry seasons, such as last summer, there is a deficiency of water in the Beaver river for the use of the machinery already erected, as I observed when there, on the 5th of last September. When this machinery is increased the difficulty will be greater, so that no reliance can be placed upon this river without great injury to the proprietors. If this be avoided by bringing the main supply from the Allegheny, the distance fed from the Mahoning islands above Kittanning to Beaver will be 79 miles. Neglecting the amount that would be supplied from the lockage water of the Beaver canal, the quantity required to supply this extent, even taking it at the minimum rate used during the extremely light business of last summer from the Kiskiminitas to Pittsburg, would be 8,058 cubic feet per minute.

This amount of water would not be sufficient for an active trade, but even this would create a current in the present sized canal, that would be a serious impediment to the navigation, and consequently the dimensions of the feeder should be increased, in proportion to the quantity of water that is to pass through it. Besides this, it would be difficult to keep up the most distant part of the line, unless the feeder be larger than the present canal.

I merely give these general views, that they may come before the Legislature in time for action, as my successor is not yet personally acquainted, with the situation of the work.

As to the different levels of the feeder, from the remarks made in my late report, I thought it possible, that an estimate of the expense of the upper level might be called for, and consequently have the notes, but have not thought it necessary to finish the estimate, unless desired so to do. The maps of both the upper and lower levels have been deposited in the canal commissioners office. These show the line as extended up to the Mahoning islands, in the Allegheny river.

Very respectfully,
B. AYCRIGG,
Civil Engineer.

ERRATA.—The following inaccuracies in the figures require alteration.

Page	8	line 30 for 800 read 600
"	12	at bottom of table, for 1 read —1
"	15	line 33 for $1.25 read 1.25 cents.